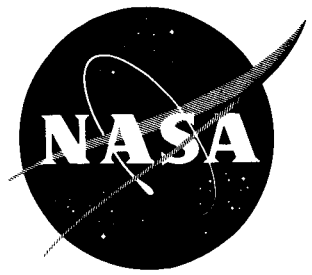
NASA TN D-207



TECHNICAL NOTE
D-207

HYDRODYNAMIC IMPACT-LOADS INVESTIGATION OF CHINE-IMMERSED 0° DEAD-RISE CONFIGURATIONS HAVING LONGITUDINAL CURVATURE

WITH AN APPENDED BIBLIOGRAPHY OF LANGLEY IMPACT BASIN HYDRODYNAMIC PUBLICATIONS

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SUMMARY

To investigate the relationship of bottom configuration to hydrodynamic impact loads, tests were made of two 0° dead-rise, narrow-beam configurations; one having the forward half curved upward, the other having the same curvature over the rear half. The tests were made in smooth water over a range of flight-path angles at several fixed trim angles with beam-loading coefficients of about 18, 29, and 36.

The load, motion, and moment data obtained at impact from both configurations and the maximum-pressure data for the curved-stern configuration are presented in tabular form. The results are plotted in coefficient form, and some typical time histories are also presented. The trends of the coefficients with initial flight-path angle, trim, and beam loading for both configurations are generally similar to those exhibited by other chine-immersed models. Comparison of the results for the two configurations at positive trims revealed no significant differences due to longitudinal curvature, but comparison at 0° trim indicated load alleviation by the curved stern.

The present investigation is the last of a program on impact loads on narrow-beam models and also the last to be reported from the recently deactivated Langley impact basin. The opportunity is therefore taken to include a bibliography of all other publications on hydrodynamic programs from this basin.

INTRODUCTION

In the design of water-based aircraft a basic problem has been that of obtaining hydrodynamic configurations with low landing-impact loads. The fundamentals of impact loads as related to seaplane body configuration were investigated for several years at the Langley impact basin.

These investigations have generally dealt with experimental studies of impact loads on basic shapes of models. From the standpoint of impact loads these tests can be grouped as wide-beam configurations (non-chine immersed) or as narrow-beam configurations (chine immersed). The data obtained on these basic configurations can be applied to the design of specific seaplane hulls or hydro-skis. The investigation with which this paper is concerned concludes the program at the Langley impact basin on narrow-beam configurations. Also, since this research facility has now been deactivated, this opportunity is taken to present a bibliography of the publications of other hydrodynamic research programs carried out at the Langley impact basin. For convenience, this bibliography is subdivided according to subject matter.

The data of the present investigation deal with the hydrodynamic impact loads on a chine-immersed 0° dead-rise model having longitudinal curvature. This investigation was part of a program dealing primarily with effects of transverse shape but included a few investigations to determine some of the effects of longitudinal curvature on impact loads. Among the configurations tested with longitudinal curvature were a concave-convex shape (ref. 1), a 30° dead-rise V-shape (ref. 2), and the flat-bottom model used for the present investigation.

This investigation is concerned with the loads and motions of two 0° dead-rise, narrow-beam configurations: one having the forward half curved upward, the other having the same curvature over the rear half. The tests consisted of a series of impacts in smooth water for a range of flight-path angles at several fixed trims. Most of the runs were made at a beam-loading coefficient of about 18 but a few runs were made at loading coefficients of 29 and 36.

The data presented in this paper include load, motion, and moment data obtained at impact from both configurations, and maximum pressure data for the curved-stern configuration. The load, motion, and moment data are presented tabularly and are plotted in coefficient form, and some typical time histories are also presented. Load, motion, moment, and time coefficients for the two configurations at two of the trims are presented in such a manner that the parameters are fixed except for the shape and initial flight-path angle against which they are plotted. These plots provide direct comparisons of some of the effects of longitudinal curvature.

SYMBOLS

b model beam, ft

F_V hydrodynamic force normal to undisturbed water surface, lb

g	acceleration due to gravity, 32.2 ft/sec^2
M_Y	pitching moment referred to stern, lb-ft
n_i	impact load factor, F_v/W
p	water pressure, lb/sq in.
t	time after water contact, sec
V	resultant velocity of model, fps
W	dropping weight, lb
$\dot{x}$	velocity of model parallel to undisturbed water surface, fps
z	model draft, ft
$\dot{z}$	vertical velocity of model, fps
γ	flight-path angle relative to undisturbed water surface, deg
ρ	mass density of water, 1.938 slugs/cu ft
τ	trim angle (angle between tangent to the keel at stern and undisturbed water surface), deg

Dimensionless variables:

C_d	draft coefficient, z/b
C_v	vertical-velocity coefficient, $\dot{z}/\dot{z}_o$
C_L	impact lift coefficient, $\dfrac{F_v}{\frac{1}{2}\rho b^2 V_o^2}$
C_m	pitching-moment coefficient, $\dfrac{M_Y}{\frac{1}{2}\rho b^3 V_o^2}$
C_{cp}	center-of-pressure coefficient, center-of-pressure distance from stern-keel point in beams
C_t	time coefficient, $\dfrac{V_o t}{b}$

C_{Δ} beam-loading coefficient, $\frac{W}{\rho g b^3}$

Subscripts:

o instant of initial contact with water surface

max maximum

APPARATUS AND TEST PROCEDURE

Basin and Models

The tests were made in the Langley impact basin with the equipment described in reference 3. This equipment consisted of a catapult, an arresting gear, a testing carriage to which the model was attached, and instrumentation for measuring the loads and motions of the model. The model was attached to the carriage at all times by a boom mounted on a parallel linkage which permitted the model to have the forward motion of the carriage and a free vertical motion while restrained in pitch, roll, and yaw.

A profile view showing pertinent dimensions of the model is shown in figure 1. The model was 10 feet in length and had a 1-foot beam. It was basically of sheet-metal construction and was designed so that any deflection under load could be considered negligible. The chines were sharp enough to insure flow separation, and the parts of the model above the chines, therefore, had no effect on the test results. The bottom was flat in transverse cross section but longitudinally one-half was flat and the other half was curved upward on a 120-inch radius. The attachment points were arranged so that either end could be used as the stern. Figure 2(a) shows the model in testing position as a curved-bow configuration at 0° trim and figure 2(b) shows it as a curved-stern configuration at 0° trim.

Instrumentation and Accuracy

The instruments consisted of accelerometers, a dynamometer, a water-contact indicator, and electrical pickups for measuring displacements, velocities, and hydrodynamic pressure. The data from these instruments were recorded on a multichannel oscillograph along with 0.01-second timing.

Accelerations were measured in the vertical direction by an unbonded strain-gage-type accelerometer having a range of $\pm 6g$ and a natural frequency of 17 cycles per second. Pitching moments about the step were

obtained from a strain-gage-type dynamometer mounted between the model and and the carriage boom. The measured moments were adjusted for the effect of the mass below the dynamometer and transferred to the step. Model contact with the water was indicated by an electric circuit completed by the water. Horizontal and vertical displacements were obtained from a photoelectric cell and slide-wire, respectively, as described in reference 3. Vertical velocity of the model was determined by means of a generator driven by the vertical movement of the carriage boom. The pressures were measured by 12 induction-type gages which had 1/2-inch-diameter diaphragms mounted flush with the model bottom and were distributed along the center line as shown in figure 3.

The apparatus used in these tests yields measurements that are believed correct within the following limits:

Horizontal velocity, ft/sec	±0.5
Vertical velocity, ft/sec	±0.2
Draft, ft	±0.03
Acceleration, g units	±0.2
Weight, lb	±10.0
Pitching moment, percent	±8.0
Pressure, percent	±10.0
Time, sec	±0.002

Test Conditions

A summary of the test conditions for both configurations is presented in table I.

The curved-bow configuration was tested at fixed trim angles of -3° to 23°. The horizontal velocity at contact was varied from approximately 20 to 72 feet per second, and the vertical velocity at contact varied from approximately 2 to 13 feet per second. These velocities resulted in a range of flight-path angles at water contact of 2.5° to 22.8°. Dropping weights of about 1,150, 1,807, and 2,264 pounds gave beam-loading coefficients C_Δ of about 18.4, 29.0, and 36.3, respectively.

The curved-stern configuration was tested at fixed trim angles (tangent to the bottom at the stern with respect to undisturbed water) of 16° to -22°. The horizontal velocity at contact was varied from approximately 33 to 90 feet per second and the vertical velocity at contact varied from approximately 5 to 13 feet per second. These velocities resulted in flight-path angles at water contact of 3.2° to 20.7°. Dropping weights of about 1,147 and 2,264 pounds gave C_Δ values of 18.4 and 36.3, respectively.

RESULTS AND DISCUSSION

The primary purpose of this investigation was to extend studies of impact loads on chine-immersed flat-bottom (zero dead-rise) bodies with upward-curved bow or upward-curved stern. The data and results presented are also of interest in the consideration of the general problem of loads on narrow-beam models. In the following paragraphs, a brief discussion of the behavior of each model is presented, together with some effects of longitudinal curvature observed in these tests.

The experimental data were obtained from the tests as time histories of draft, vertical velocity, vertical acceleration, pitching moment, and hydrodynamic bottom pressure. The values of the initial conditions and the recorded motion, load, and moment data at maximum acceleration, maximum draft, and rebound are given in table II. The data for both configurations are given in this table, the first 96 runs being for the curved-bow configuration and the other 72 for the curved-stern configuration. The maximum pressure recorded on each gage and the time after contact at which this pressure occurred are given in table III for the curved-stern configuration. The initial conditions for each run are also repeated for convenience.

Time histories of the coefficients of draft, vertical velocity, hydrodynamic lift, pitching moment about the step, and center of pressure from contact to the time of maximum draft are presented in figure 4 for three typical runs. These time histories give an overall picture of the sequence of events during the runs. They were chosen to illustrate the effect on the results of varying certain test conditions.

Figures 4(a) and 4(b) represent for the curved-bow configuration the effect of increasing trim while maintaining other parameters approximately constant. It can be noted from these plots that as trim increases, although the maximum draft coefficient C_d remains almost constant, the maximum impact-lift coefficient C_L is reduced but the lift coefficient is maintained for a longer period and the moment and center-of-pressure coefficients are reduced. Figures 4(a) and 4(c) show that for the low trim condition, the curved stern considerably reduced the maximum lift and moment coefficients and caused the center of pressure to remain near the stern. Actually, the results for the curved-stern configuration at 0° trim (fig. 4(c)) resemble the results for the curved-bow configuration at 23° trim (fig. 4(b)). It should be noted, however, that at high trims the curved bow does not become immersed and, therefore, this configuration is essentially a straight-keel configuration.

As a means of analyzing the results, the data given in table II were converted into dimensionless coefficient form. In this manner the results

obtained for each impact can be compared with results of all the other impacts, with trim and flight-path angle being the only variables for a given shape and beam-loading condition. The draft coefficients at the instants of maximum draft and maximum acceleration, the vertical-velocity coefficients at maximum acceleration and at rebound, the maximum impact-lift coefficient, the pitching-moment and center-of-pressure coefficients at the instant of maximum acceleration, and the time coefficients at maximum acceleration, maximum draft, and rebound were computed from the experimental data. These experimental coefficients were then plotted in figures 5, 6, 7, 8, 9, and 10 against initial flight-path angle for each trim and beam-loading coefficient.

In figure 5 the trend of draft coefficient with initial flight-path angle at each tested trim and beam loading can be directly observed from the plots. The trends with trim and with beam loading can be observed by comparing the plots for a given configuration with each other, and effects of longitudinal curvature can be observed by comparing the plots of figure 5(a) with those of figure 5(b). It should be noted that for the curved-bow configuration (fig. 5(a)) a line is drawn on the positive trim plots indicating the draft coefficient at which geometric bow immersion begins. The positions of these lines indicate that for trims above 3°, the bow was not immersed at the time of maximum acceleration, and these data can be considered essentially straight-keel data. However, for the lower trim data and most of the maximum-draft data at the intermediate trims, the bow was immersed for at least a part of the impact.

The trends of vertical velocity, maximum-impact lift, pitching moment, center-of-pressure, and time coefficients with initial flight-path angle, trim, and beam-loading coefficient can be observed in figures 6, 7, 8, 9, and 10, respectively, in a manner similar to that described for the draft coefficient in figure 5. Likewise, some effects of longitudinal curvature can be observed by comparing the (a) and (b) parts of each figure. The trends of the coefficients with initial flight-path angle, trim, and beam loading are in general similar to those described in references 1 and 2 and will not all be discussed individually.

In order to compare more directly the effects of longitudinal curvature, figure 11 presents curves of the draft, vertical-velocity, impact-lift, pitching-moment, center-of-pressure, and time coefficients obtained by fairing the data as presented in figures 5, 6, 7, 8, 9, and 10 at a draft coefficient of 18 for 8° and 0° of trim. In this manner the parameters have been fixed except for the shape of the configuration and the initial flight-path angle, against which the coefficients are plotted.

From the comparison at 8° trim (fig. 11(a)) no large differences between the results for the two configurations are apparent. The curved-stern configuration went only slightly deeper into the water than the

curved-bow configuration at both maximum load and maximum draft. The trends of the vertical velocities at both maximum load and exit are similar. The maximum lift, moment, and center-of-pressure coefficients indicate no significant differences for the configurations. Among the time coefficients the only appreciable difference is that at exit which shows that the curved-stern configuration leaves the water in a considerably shorter time than the curved-bow configuration.

In the 0° trim case (fig. 11(b)) the curved-stern configuration attains considerably greater drafts than the curved-bow configuration, especially at maximum load which the curved-bow configuration attains at very shallow drafts. The curved-bow configuration has quite high vertical velocities at maximum load and very small vertical velocities at exit, while the curved-stern configuration does not show much change from the 8° trim condition. The curved-stern configuration has much lower values of maximum lift, moment, and center of pressure than the curved-bow configuration. From the time coefficient plot can be seen that the curved-bow configuration attains maximum load almost instantly on contact and requires less time to exit at high flight-path angles than at low ones; while the curved-stern configuration has the opposite trend.

Thus, the comparison of the two configurations at 0° trim shows considerable difference in the results. The curved-bow configuration, which has a large flat area involved immediately on contact at this attitude, shows a much larger and more rapid buildup of load than the curved-stern configuration. Thus, the stern curvature can be looked upon, in this instance, as a load-relieving device which by spreading the impact over more time and a deeper immersion attains a reduction of the maximum loads and moments. This effect could be of importance in rough-water landings where low-trim, high effective flight-path angle impacts that produce large loads are common.

CONCLUDING REMARKS

Hydrodynamic impact tests were made in the Langley impact basin using two 0° dead-rise, narrow-beam configurations; one having longitudinal upward curvature over the forward half, the other having the same curvature over the rear half. The tests were made in smooth water for a range of flight-path angles at several fixed trims with beam loading coefficients of about 18, 29, and 36.

The trends of the coefficients with initial flight-path angle, trim, and beam loading, for both configurations are generally similar to those exhibited by other chine-immersed models.

Comparisons between the results for the two configurations at positive trims have revealed only small differences in behavior due to longitudinal curvature. However, comparison at 0° trim shows that the curved-bow configuration, which has a large flat area involved immediately on contact at this attitude, has a large rapid buildup of load and moment. On the other hand, the curved-stern configuration, which spreads the impact over more time and a deeper immersion, attains a considerable reduction of the maximum loads and moments. This reduction of loads and moments could be of importance in rough-water landings, where low trim, high effective flight-path-angle impacts are common.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., October 23, 1959.

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TABLE I.- SUMMARY OF TEST CONDITIONS

Beam-loading coefficient, C_{Δ}	Weight, W, lb	Trim angle, τ, deg	Initial-flight-path angle, γ_o, deg	Velocity range, V_o, fps	Number of runs
Curved-bow configuration					
18.30	1,142	-3, 0, 3, 8, 13, 23	2.5 to 22.7	19 to 68	39
18.59	1,161	3, 8, 13, 23	3.7 to 22.8	31 to 69	34
28.96	1,807	8	4.1 to 21.9	22 to 70	9
36.28	2,264	8	3.0 to 21.5	23 to 72	14
Curved-stern configuration					
18.38	1,147	16, 8, 0, -8, -14, -22	3.2 to 20.7	33 to 90	68
36.28	2,264	0	3.5 to 19.2	36 to 87	4

TABLE II.- IMPACT TEST DATA

(a) Curved-bow configuration

Run	C_Δ	At contact				At $n_{i_{max}}$					At z_{max}		At rebound	
		$\dot{x}_o$, fps	$\dot{z}_o$, fps	V_o, fps	γ_o, deg	t, sec	n_i	z, ft	$\dot{z}$, fps	M_Y, lb-ft	t, sec	z, ft	t, sec	$\dot{z}$, fps
$\tau = -3^\circ$														
1	18.3	47.2	3.0	47.3	3.70	0.144	0.4	0.30	1.0	3,700	0.248	0.34	0.708	-0.6
2	18.3	43.9	4.1	44.1	5.38	.108	.4	.32	2.5	3,893	.278	.49	.779	-.6
3	18.3	38.5	5.6	38.9	8.30	.035	.8	.17	5.0	5,396	.288	.69	.889	-1.0
4	18.3	34.0	6.4	34.6	10.72	.034	1.0	.16	5.5	6,197	.317	.82	1.127	-.4
$\tau = 0^\circ$														
5	18.3	47.2	2.6	47.2	3.21	0.028	0.4	0.06	2.3	1,672	0.246	0.27	0.786	-.2
6	18.3	42.6	3.9	42.7	5.26	.010	.5	.04	3.8	2,031	.276	.42	-----	----
7	18.3	38.6	5.9	39.1	8.72	.026	1.3	.13	5.0	6,084	.292	.65	.551	-1.0
8	18.3	33.6	5.7	34.0	9.57	.026	1.2	.12	4.8	5,319	.322	.67	-----	----
$\tau = 3^\circ$														
9	18.3	45.3	2.0	45.3	2.52	0.042	0.3	0.07	1.7	486	0.272	0.22	-----	----
10	18.3	65.1	3.2	65.2	2.85	.028	.6	.18	2.5	1,721	.205	.30	.626	-.8
11	18.3	53.8	2.8	53.9	2.98	.064	.5	.15	2.0	1,046	.234	.28	.731	-.5
12	18.3	54.9	2.9	55.0	2.98	.050	.5	.14	2.4	1,364	.230	.30	.814	-.6
13	18.3	55.9	3.0	56.0	3.08	.020	.5	.13	2.4	641	.220	.31	-----	----
14	18.3	38.9	2.3	39.0	3.34	.052	.3	.11	1.9	1,024	.312	.28	-----	----
15	18.3	55.6	3.4	55.7	3.43	.063	.6	.18	2.6	1,639	.243	.35	.768	-.7
16	18.3	56.0	3.4	56.1	3.51	.054	.6	.15	2.7	2,302	.234	.33	.680	-.4
17	18.3	47.6	3.0	47.7	3.56	.058	.5	.15	2.3	1,511	.283	.33	.928	-.4
18	18.3	55.8	3.5	55.9	3.57	.062	.6	.18	2.5	1,523	.220	.34	.710	-.8
19	18.6	51.6	3.4	51.7	3.74	.073	.6	.20	2.3	1,106	.236	.34	.792	-.5
20	18.6	52.9	3.5	53.0	3.78	.049	.5	.14	2.8	355	.229	.32	.847	-.3
21	18.6	69.0	9.0	69.6	7.45	.043	2.3	.32	6.6	5,483	.193	.63	.573	-1.3
22	18.6	66.0	9.2	66.7	7.98	.044	2.3	.32	6.8	6,004	.193	.63	.595	-1.9
23	18.3	38.5	5.8	38.9	8.49	.055	1.0	.22	5.2	2,887	.317	.75	-----	----
24	18.6	53.5	10.8	54.6	11.37	.042	2.7	.40	8.0	8,170	.212	.84	.731	-1.8
25	18.6	52.9	11.1	54.1	11.89	.030	2.6	.35	8.7	7,530	.223	.88	.738	-1.8
26	18.3	28.2	6.9	29.0	13.81	.026	1.1	.18	6.5	3,185	.385	.97	-----	----
27	18.6	41.3	11.2	42.8	15.11	.041	2.6	.39	8.9	7,223	.283	1.71	.982	-1.2
28	18.6	40.2	11.4	41.8	15.47	.041	2.5	.54	9.2	7,562	.273	1.23	.955	-1.4
29	18.6	31.9	11.1	33.8	19.24	.044	2.4	.45	9.7	6,465	.322	1.37	-----	----
30	18.6	32.3	12.3	34.6	20.84	.042	2.6	.43	9.6	7,648	.320	1.28	-----	----
31	18.6	32.0	12.3	34.2	21.06	.044	2.8	.44	9.6	8,773	.341	1.31	-----	----
32	18.3	19.8	8.3	21.5	22.67	.030	1.3	.30	6.9	4,680	.430	1.27	1.246	-1.2
33	18.6	32.2	12.2	34.4	22.84	.041	2.7	.46	9.7	8,360	.320	1.32	-----	----
$\tau = 8^\circ$														
34	18.3	51.8	2.6	51.9	2.86	0.095	0.5	0.20	1.5	1,488	0.195	0.27	0.515	-1.2
35	18.3	68.0	3.5	68.1	2.95	.058	.9	.16	2.4	1,101	.138	.27	.331	-2.0
36	18.3	54.6	3.0	54.7	3.11	.080	.6	.11	2.8	1,020	.170	.26	.420	-1.4
37	18.3	64.5	7.0	64.9	6.23	.050	1.6	.32	5.2	2,982	.170	.55	.430	-3.1
38	18.6	67.6	9.2	68.2	7.74	.062	1.4	.36	5.8	3,470	.158	.54	.395	-3.8
39	18.6	65.4	9.3	66.0	8.21	.065	2.0	.45	6.0	4,473	.163	.66	.547	-3.9
40	18.3	37.6	5.4	38.0	8.25	.060	.7	.30	4.2	1,538	.290	.60	.819	-1.5
41	18.3	38.9	5.8	39.3	8.41	.071	.8	.42	4.0	2,984	.254	.72	.855	-1.3
42	18.6	54.4	10.9	55.4	11.37	.058	2.2	.53	8.0	3,804	.198	.92	.585	-3.6
43	18.6	53.9	11.1	55.0	11.68	.053	2.1	.48	8.4	2,683	.202	.90	.609	-3.3
44	18.3	26.5	7.0	27.4	14.88	.058	.9	.41	6.1	2,371	.378	1.10	-----	----
45	18.6	42.4	11.7	44.0	15.44	.058	2.1	.55	8.6	3,985	.260	1.10	.822	-2.6
46	18.6	41.5	11.5	43.1	15.54	.062	2.0	.58	8.4	3,555	.251	1.13	.830	-2.7
47	18.3	21.1	7.6	22.4	19.93	.057	1.1	.48	6.1	3,722	.427	1.46	-----	----
48	18.6	33.4	12.4	35.6	20.27	.061	2.0	.64	9.3	4,577	.316	1.43	1.108	-1.9
49	18.6	33.2	12.4	35.4	20.45	.071	1.9	.61	9.3	4,056	.322	1.41	1.079	-2.0
50	18.6	33.1	12.4	35.4	20.59	.058	2.0	.61	9.5	3,785	.300	1.38	1.116	-1.8
51	18.6	32.0	12.3	34.2	21.06	.059	1.9	.59	9.1	4,782	.306	1.34	1.147	-1.8

TABLE II.- IMPACT TEST DATA - Continued

(a) Curved-bow configuration - Concluded

Run	C_Δ	At contact				At $n_{i_{max}}$					At z_{max}		At rebound	
		$\dot{x}_o$, fps	$\dot{z}_o$, fps	V_o, fps	γ_o, deg	t, sec	n_i	z, ft	$\dot{z}$, fps	M_Y, lb-ft	t, sec	z, ft	t, sec	$\dot{z}$, fps
$\tau = 13^\circ$														
52	18.3	45.7	3.1	45.8	3.93	0.098	0.6	0.24	2.0	1,118	0.194	0.30	0.442	-1.7
53	18.6	67.8	9.7	68.5	8.18	.069	2.4	.48	5.7	2,514	.141	.63	.354	-5.0
54	18.6	65.6	9.4	66.2	8.18	.074	2.4	.55	5.2	2,901	.135	.62	.470	-5.2
55	18.3	38.6	7.6	39.4	11.18	.080	1.2	.52	5.7	3,437	.240	.72	.678	-2.8
56	18.6	53.5	11.0	54.6	11.58	.070	2.2	.58	7.3	2,588	.183	.86	.477	-4.8
57	18.3	25.2	6.2	26.0	13.77	.101	.7	.53	4.5	2,182	.351	1.01	1.222	-.7
58	18.3	37.1	9.2	38.2	13.95	.070	1.5	.57	6.8	-----	.250	1.09	.757	-2.7
59	18.6	45.4	11.4	46.9	14.08	.072	2.1	.64	8.0	2,598	.215	1.03	.585	-4.4
60	18.6	41.1	10.8	42.5	14.73	.075	1.8	.64	7.3	2,538	.223	1.04	.650	-3.7
61	18.3	22.5	8.1	23.9	19.80	.069	.9	.53	6.9	2,840	.399	1.04	-----	----
62	18.6	32.7	12.1	34.9	20.26	.078	1.7	.74	8.7	3,161	.288	1.39	.932	-2.9
63	18.6	32.3	12.1	34.4	20.53	.073	2.2	.70	9.0	2,975	.293	1.38	.929	-3.0
64	18.3	23.0	9.0	24.8	21.45	.078	1.1	.65	7.2	3,713	.388	1.50	1.404	-1.2
$\tau = 23^\circ$														
65	18.3	48.9	3.8	49.0	4.48	0.109	0.9	0.30	1.8	1,012	0.159	0.33	0.358	-2.8
66	18.6	64.7	9.5	65.4	8.32	.082	2.7	.52	4.0	2,410	.106	.56	.264	-6.6
67	18.3	40.0	6.3	40.5	8.89	.105	1.0	.53	4.0	1,850	.220	.72	.516	-3.6
68	18.6	53.5	10.9	54.6	11.49	.086	2.3	.65	6.0	2,068	.156	.80	.368	-6.5
69	18.3	29.1	8.0	30.2	15.46	.135	.9	.86	5.0	1,871	.310	1.21	.826	-3.1
70	18.6	40.6	10.8	42.0	16.81	.077	1.8	.73	6.8	2,273	.206	1.04	.531	-5.4
71	18.3	25.6	9.6	27.3	20.49	.124	1.0	.99	6.4	2,524	.350	1.55	1.024	-2.9
72	18.6	31.8	11.9	34.0	20.55	.109	1.6	.99	7.3	2,687	.268	1.42	.762	-4.3
73	18.6	31.6	12.1	33.8	21.02	.096	1.6	.91	8.3	2,565	.291	1.43	.802	-4.3
$\tau = 8^\circ$														
74	29.0	49.0	4.2	49.2	4.87	0.103	0.5	0.36	2.9	2,195	0.288	0.59	0.778	-1.6
75	29.0	56.2	5.4	56.4	5.44	.094	.5	.28	2.4	1,213	.224	.40	.572	-1.7
76	29.0	69.9	10.5	70.7	8.51	.075	1.8	.60	6.9	7,623	.214	.95	.564	-4.3
77	29.0	38.8	6.5	39.3	9.56	.093	.8	.53	4.7	4,864	.377	1.09	1.187	-1.3
78	29.0	58.5	11.3	59.6	10.95	.069	1.2	.60	8.1	8,930	.248	1.14	.667	-3.8
79	29.0	44.8	12.4	46.5	15.40	.069	1.8	.66	9.2	8,326	.312	1.48	.983	-2.7
80	29.0	22.1	8.3	23.6	20.49	.092	.8	.67	6.9	5,703	.466	1.62	1.630	-.7
81	29.0	33.0	12.8	35.4	21.12	.071	1.6	.70	9.9	8,387	.405	1.88	1.400	-1.7
82	29.0	31.8	12.8	34.2	21.88	.066	1.6	.72	10.0	8,252	.406	2.16	1.421	-4.7
83	36.3	61.5	3.2	61.6	2.96	.118	0.5	0.30	2.0	2,498	0.233	0.38	0.555	-2.0
84	36.3	55.2	3.2	55.3	3.33	.126	.4	.31	1.9	2,520	.261	.41	.643	-1.7
85	36.3	71.7	4.2	71.8	3.37	.118	.7	.33	2.4	3,595	.209	.42	.475	-2.3
86	36.3	68.5	4.3	68.6	3.60	.107	.6	.31	2.0	3,048	.207	.40	.492	-2.2
87	36.3	48.1	4.0	48.2	4.82	.110	.4	.37	2.7	2,557	.320	.61	.825	-1.8
88	36.3	40.7	5.9	41.2	8.20	.172	.6	.51	4.4	4,165	.450	1.01	1.132	-1.9
89	36.3	68.0	10.5	68.8	8.56	.064	1.7	.57	8.0	9,852	.238	1.09	.631	-4.6
90	36.3	58.5	11.2	59.5	10.84	.061	1.6	.62	9.0	10,203	.276	1.30	.776	-4.2
91	36.3	34.7	7.8	35.6	12.65	.090	.7	.62	6.2	5,489	.430	1.50	1.338	-1.7
92	36.3	44.0	11.5	45.5	14.68	.069	1.4	.72	9.3	9,098	.344	1.66	.972	-3.2
93	36.3	23.0	6.2	23.8	15.15	.144	.4	.74	4.6	3,699	.570	1.52	1.754	-1.0
94	36.3	32.7	10.8	33.4	18.29	.072	1.3	.76	10.6	9,207	.442	2.19	1.411	-2.6
95	36.3	23.6	8.3	25.3	19.11	.094	.7	.69	6.8	5,796	.554	1.97	1.654	-1.9
96	36.3	32.7	12.9	35.2	21.53	.068	1.4	.76	10.4	8,205	.462	2.29	1.478	-2.6

TABLE II.- IMPACT TEST DATA - Continued

(b) Curved-stern configuration

Run	C_Δ	At contact				At $n_{i_{max}}$					At z_{max}		At rebound	
		$\dot{x}_o$, fps	$\dot{z}_o$, fps	V_o, fps	γ_o, deg	t, sec	n_i	z, ft	$\dot{z}$, fps	M_Y, lb-ft	t, sec	z, ft	t, sec	$\dot{z}$, fps
$\tau = -22^\circ$														
97	18.4	89.3	5.0	89.4	3.24	0.070	1.1	0.29	3.3	8,058	0.157	0.40	0.418	-1.6
98	18.4	83.3	4.9	83.5	3.34	.071	1.2	.26	2.9	9,475	.143	.35	.377	-1.7
99	18.4	78.7	8.0	79.2	5.84	.073	1.7	.44	4.9	13,780	.168	.62	.462	-2.6
100	18.4	73.8	8.1	74.2	6.29	.057	1.7	.38	5.8	11,772	.177	.65	.494	-2.4
101	18.4	67.1	8.7	67.7	7.39	.058	1.6	.41	6.3	12,507	.192	.71	.657	-2.4
102	18.4	62.5	8.1	63.0	7.41	.063	1.5	.40	6.0	10,865	.212	.74	.648	-1.9
103	18.4	49.6	7.7	50.2	8.78	.056	1.1	.35	5.9	7,795	.266	.81	.894	-.8
104	18.4	46.7	8.1	47.4	9.83	.056	1.2	.37	6.4	8,253	.289	.89	.968	-1.4
105	18.4	54.0	9.9	55.0	10.40	.056	1.8	.45	7.5	12,777	.275	.96	.943	-1.8
$\tau = -14^\circ$														
106	18.4	85.1	4.9	85.2	3.31	0.080	1.4	0.30	2.7	8,542	0.124	0.35	0.284	-3.6
107	18.4	82.0	4.9	82.1	3.34	.080	1.1	.32	3.1	6,613	.152	.40	.417	-1.4
108	18.4	80.3	11.2	81.1	7.95	.061	2.6	.50	7.6	15,825	.147	.76	.359	-4.9
109	18.4	80.0	12.4	81.0	8.84	.054	2.8	.54	8.8	17,028	.151	.89	.402	-4.5
110	18.4	62.1	12.4	63.3	11.29	.027	2.5	.28	11.0	10,393	.185	.96	.502	-3.8
111	18.4	61.7	12.5	63.0	11.47	.025	2.4	.27	10.9	9,616	.184	1.04	.507	-4.2
112	18.4	61.1	12.5	62.4	11.58	.025	2.5	.29	11.0	9,948	.185	1.04	.497	-4.3
113	18.4	43.7	12.4	45.4	15.85	.027	2.5	.29	10.9	8,731	.258	1.28	.777	-2.8
114	18.4	42.7	12.6	44.5	16.41	.025	2.4	.28	11.2	7,946	.254	1.28	.759	-3.1
115	18.4	34.0	12.5	36.2	20.15	.024	2.4	.28	11.0	7,596	.316	1.51	1.050	-2.0
116	18.4	33.1	12.4	35.3	20.46	.014	2.4	.27	11.0	7,635	.321	1.48	1.105	-1.6
$\tau = -8^\circ$														
117	18.4	84.0	4.9	84.2	3.35	0.118	1.1	0.37	1.7	5,981	0.150	0.38	0.403	-1.6
118	18.4	79.4	10.5	80.1	7.52	.079	2.4	.59	5.6	13,682	.142	.73	.368	-4.4
119	18.4	62.1	12.3	63.3	11.21	.027	2.6	.29	10.9	8,585	.182	.98	.487	-4.3
120	18.4	43.8	12.0	45.4	15.33	.025	2.2	.28	10.8	6,342	.250	1.24	.705	-3.4
121	18.4	34.0	12.1	36.1	19.57	.025	2.2	.27	10.9	5,660	.315	1.48	1.000	-2.1
$\tau = 0^\circ$														
122	18.4	84.0	4.9	84.2	3.32	0.063	1.3	0.24	3.0	4,586	0.130	0.32	0.325	-2.2
123	18.4	84.8	5.0	84.9	3.35	.071	1.2	.27	3.0	3,710	.138	.35	.340	-2.4
124	18.4	78.4	9.3	79.0	6.74	.058	2.1	.43	6.4	7,680	.146	.64	.391	-3.7
125	18.4	80.0	10.3	80.6	7.32	.055	2.5	.47	7.3	8,697	.142	.73	.370	-4.4
126	18.4	78.4	10.4	79.1	7.55	.055	2.5	.47	7.4	8,913	.138	.72	.361	-4.5
127	18.4	74.1	10.0	74.8	7.70	.057	2.3	.46	7.1	8,106	.152	.70	.389	-4.2
128	18.4	73.0	10.0	73.7	7.84	.058	2.4	.45	6.8	8,678	.142	.66	.365	-4.4
129	18.4	73.5	12.1	74.5	9.38	.061	2.8	.57	7.9	11,053	.149	.83	.384	-5.5
130	18.4	61.4	12.1	62.5	11.19	.057	2.4	.56	8.9	9,219	.184	.98	.489	-4.4
131	18.4	61.7	12.2	62.9	11.20	.063	2.6	.60	8.4	10,247	.178	.99	.485	-4.1
132	18.4	60.6	12.2	61.8	11.40	.058	2.6	.60	8.8	9,348	.186	1.01	.487	-4.5
133	18.4	60.4	12.2	61.6	11.43	.059	2.6	.58	8.7	9,841	.172	.98	.471	-4.5
134	18.4	45.2	12.2	46.8	15.14	.057	2.1	.60	9.4	7,501	.238	1.27	.674	-3.6
135	18.4	43.2	12.4	44.9	16.03	.058	2.1	.61	9.5	7,539	.243	1.29	.691	-3.4
136	18.4	42.6	12.4	44.3	16.30	.056	2.0	.62	9.4	7,166	.246	1.28	.719	-3.3
137	18.4	38.8	12.3	40.7	17.62	.058	2.0	.57	9.6	8,091	.275	1.30	.816	-2.7
138	18.4	38.5	12.3	40.4	17.69	.057	1.9	.59	9.7	6,149	.276	1.37	.809	-2.9
139	18.4	38.8	12.4	40.7	17.74	.056	1.8	.58	10.0	6,853	.280	1.39	.812	-3.0
140	18.4	34.0	12.0	36.1	19.45	.055	1.7	.57	9.8	5,563	.295	1.48	.962	-2.2
141	18.4	33.7	12.3	35.8	20.02	.053	1.7	.61	9.8	6,621	.301	1.55	.965	-2.3
142	18.4	33.1	12.5	35.4	20.73	.054	1.8	.60	10.1	6,217	.301	1.53	.969	-2.2
143	36.3	87.3	5.4	87.5	3.53	.147	.9	.54	2.4	8,135	.209	.59	.522	-2.2
144	36.3	76.9	10.8	77.7	7.99	.083	1.7	.73	7.4	15,204	.213	1.14	.538	-4.9
145	36.3	43.7	12.6	45.5	16.10	.149	1.3	1.38	7.2	13,933	.349	1.94	.992	-3.7
146	36.3	36.3	12.6	38.4	19.19	.150	1.2	1.46	7.7	13,121	.420	2.26	1.335	-2.2

TABLE II.- IMPACT TEST DATA - Continued

(b) Curved-stern configuration - Concluded

Run	C_Δ	At contact				At $n_{i_{max}}$					At z_{max}		At rebound	
		$\dot{x}_o$, fps	$\dot{z}_o$, fps	V_o, fps	γ_o, deg	t, sec	n_i	z, ft	$\dot{z}$, fps	M_Y, lb-ft	t, sec	z, ft	t, sec	$\dot{z}$, fps
$\tau = 8^o$														
147	18.4	84.8	5.0	84.9	3.35	0.071	1.6	0.24	2.4	4,272	0.106	0.26	0.211	-2.6
148	18.4	78.4	9.5	79.0	6.89	.068	2.7	.50	5.6	7,853	.128	.63	.308	-5.2
149	18.4	74.1	9.7	74.7	7.43	.070	2.7	.50	5.6	8,239	.133	.64	.325	-5.2
150	18.4	74.1	9.7	74.7	7.46	.072	2.5	.52	5.6	7,273	.135	.66	.340	-5.0
151	18.4	74.4	9.8	75.0	7.50	.069	2.6	.51	5.7	7,940	.131	.63	.316	-5.4
152	18.4	61.7	12.1	62.9	11.13	.066	2.8	.66	8.1	8,965	.154	.96	.419	-5.5
153	18.4	42.6	12.0	44.2	15.76	.066	2.0	.68	9.0	6,336	.233	1.28	.667	-4.0
154	18.4	39.7	12.4	41.6	17.41	.067	2.0	.67	9.8	6,563	.267	1.43	.757	-3.7
155	18.4	39.5	12.4	41.4	17.44	.063	1.9	.69	9.7	5,952	.265	1.42	.738	-3.8
156	18.4	38.6	12.4	40.6	17.81	.063	1.9	.67	9.8	6,187	.268	1.42	.758	-3.6
157	18.4	35.1	11.6	37.0	18.31	.063	1.6	.66	9.2	4,910	.287	1.49	.877	-2.9
$\tau = 16^o$														
158	18.4	84.0	6.1	84.3	4.17	0.083	2.4	0.32	1.6	5,729	0.093	0.32	0.201	-5.0
159	18.4	74.1	9.9	74.7	7.63	.082	2.9	.57	4.4	7,062	.120	.64	.277	-6.8
160	18.4	73.5	10.2	74.2	7.91	.082	3.0	.57	4.5	6,866	.121	.63	.279	-6.9
161	18.4	73.0	10.3	73.7	8.04	.078	2.9	.58	5.0	7,609	.121	.65	.288	-6.7
162	18.4	67.8	10.0	68.5	8.40	.084	2.7	.62	5.0	6,986	.133	.71	.314	-6.5
163	18.4	51.4	11.4	52.7	12.55	.084	2.2	.75	7.0	6,278	.187	1.04	.470	-5.9
164	18.4	42.5	12.1	44.2	15.89	.085	1.9	.84	8.3	5,708	.225	1.30	.598	-5.1
165	18.4	39.1	12.6	41.0	17.84	.081	1.9	.85	9.0	5,953	.239	1.44	.659	-5.2
166	18.4	39.2	12.6	41.2	17.84	.081	2.0	.84	8.9	6,287	.234	1.39	.634	-5.2
167	18.4	38.8	12.6	40.8	18.03	.082	2.0	.82	9.0	5,955	.237	1.38	.747	-5.1
168	18.4	33.9	12.0	36.0	19.57	.083	1.6	.84	9.0	5,049	.280	1.55	.800	-3.9

TABLE III.- MAXIMUM PRESSURES AND TIME TO PEAK FOR CURVED-STERN CONFIGURATION

Run	Initial conditions			Pressure gage																					
				1		2		3		4		5		6		7		8		9		10		11		12	
	C_Δ	V_o, fps	γ_o, deg	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.	t, sec	p, lb/sq in.
$\tau = -2^\circ$																									
97	18.4	89.4	3.24	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	0.002	46	0.018	79	0.041	59	-----	--	-----	--
98	18.4	89.5	3.34	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	.008	62	.024	79	.058	67	0.116	56	-----	--
99	18.4	79.2	5.84	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	0.002	42	.008	62	.024	79	.058	67	.116	56	-----	--
100	18.4	74.2	6.29	-----	--	-----	--	-----	--	-----	--	-----	--	0.002	22	-----	--	.004	57	.013	58	.026	69	.067	49	0.119	49
101	18.4	67.7	7.39	-----	--	-----	--	-----	--	-----	--	-----	--	.002	22	-----	--	.004	50	.016	53	.039	70	.067	43	.103	47
102	18.4	63.0	7.41	-----	--	-----	--	-----	--	-----	--	-----	--	.001	19	-----	--	.004	51	-----	--	.042	70	.058	56	.092	36
103	18.4	56.2	8.78	-----	--	-----	--	-----	--	-----	--	-----	--	.001	24	-----	--	.004	46	.013	50	.034	62	.062	28	.095	57
104	18.4	47.4	9.83	-----	--	-----	--	-----	--	-----	--	-----	--	.002	22	-----	--	.005	42	-----	--	.033	47	.065	--	.071	20
105	18.4	55.0	10.40	-----	--	-----	--	-----	--	-----	--	-----	--	.002	27	.002	43	.005	42	-----	--	.029	66	.049	64	.092	55
$\tau = -4^\circ$																									
106	18.4	85.2	3.31	-----	--	-----	--	-----	--	-----	--	0.001	20	0.005	80	0.013	14	0.052	67	0.096	50	-----	--	-----	--	-----	--
107	18.4	82.1	3.34	0.028	34	0.009	42	0.005	22	0.002	18	.001	15	.006	28	.010	30	.004	61	-----	--	-----	--	-----	--	-----	--
108	18.4	81.1	7.99	.016	8	.014	11	-----	--	-----	--	.002	45	.004	26	.014	48	.028	74	.048	74	0.042	40	-----	--	-----	--
109	18.4	81.0	8.84	-----	--	-----	--	-----	--	-----	--	.002	34	.004	89	.010	41	.024	82	.044	78	.086	59	-----	--	-----	--
110	18.4	63.3	11.29	.008	19	-----	--	.009	40	.004	26	.002	44	.004	44	.012	46	.021	74	.037	67	.047	49	0.133	35	-----	--
111	18.4	63.0	11.47	-----	--	-----	--	-----	--	-----	--	.002	28	-----	--	.008	82	.022	68	.038	64	.076	45	.147	33	-----	--
112	18.4	62.4	11.58	-----	--	-----	--	-----	--	-----	--	.001	29	.002	91	.009	79	.020	68	.039	63	.071	47	.139	33	-----	--
113	18.4	45.4	15.85	-----	--	-----	--	-----	--	-----	--	.002	34	.003	51	.009	56	.019	50	.039	48	.069	33	.110	26	0.188	16
114	18.4	44.5	16.41	.008	8	.006	15	.004	45	.002	34	.001	30	.002	31	.011	49	.021	42	.039	49	.071	34	.125	29	.202	11
115	18.4	36.2	20.15	-----	--	.009	20	-----	--	-----	--	.002	26	-----	--	.006	54	.019	45	.036	51	.066	28	.106	26	.164	14
116	18.4	35.5	20.46	.007	12	.006	18	.005	42	.002	34	-----	--	.002	58	.018	56	.019	29	.031	50	.044	28	.105	25	.161	10
$\tau = -6^\circ$																									
117	18.4	84.2	3.35	-----	--	0.001	11	0.001	30	0.006	30	0.014	77	0.030	83	0.044	85	-----	--	-----	--	-----	--	-----	--	-----	--
118	18.4	80.1	7.50	0.008	20	.001	16	.002	23	.004	52	.007	65	.014	107	.028	126	0.056	67	0.115	59	-----	--	-----	--	-----	--
119	18.4	63.3	11.21	.007	34	.001	25	.002	44	.004	31	-----	--	.012	109	.028	46	.041	94	.082	46	-----	--	-----	--	-----	--
120	18.4	45.4	15.33	.007	34	.001	26	.003	33	.004	44	.007	77	.013	59	.021	46	.026	56	.050	36	0.114	19	-----	--	-----	--
121	18.4	36.1	19.57	.004	40	.001	26	.002	50	.003	40	.007	75	.013	56	.023	66	.024	63	.050	63	.157	16	-----	--	-----	--
$\tau = 0^\circ$																									
122	18.4	84.2	3.52	0.009	29	0.014	56	0.024	98	0.042	99	0.070	64	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
123	18.4	84.9	3.55	.007	69	.017	99	.040	67	.074	61	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
124	18.4	79.0	6.74	.004	49	.008	65	.017	65	.027	79	-----	--	0.065	65	0.109	47	-----	--	-----	--	-----	--	-----	--	-----	--
125	18.4	80.6	7.32	-----	--	.009	117	-----	--	.040	82	-----	--	.074	99	.144	48	-----	--	-----	--	-----	--	-----	--	-----	--
126	18.4	79.1	7.66	.009	47	.008	61	.015	80	.024	82	.041	79	.055	69	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
127	18.4	74.8	7.70	.006	65	.010	108	.017	71	.026	93	.037	49	.055	70	.080	54	-----	--	-----	--	-----	--	-----	--	-----	--
128	18.4	73.7	7.84	.009	61	.009	102	.016	74	.025	88	.036	46	.051	71	.076	55	-----	--	-----	--	-----	--	-----	--	-----	--
129	18.4	74.5	9.38	.004	46	.008	115	.012	75	.020	150	.030	53	.044	69	.060	59	-----	--	-----	--	-----	--	-----	--	-----	--
130	18.4	68.5	11.13	.002	50	.007	49	.012	54	.019	74	.027	71	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
131	18.4	68.9	11.26	.003	55	.007	61	.012	109	.024	85	.026	75	.042	51	.059	51	0.144	17	-----	--	-----	--	-----	--	-----	--
132	18.4	61.8	11.40	-----	--	.006	50	.012	58	.020	76	.027	74	.042	51	.062	46	.125	20	-----	--	-----	--	-----	--	-----	--
133	18.4	61.6	11.43	.002	40	.006	66	.013	54	-----	--	-----	--	.045	61	.061	52	.124	30	-----	--	-----	--	-----	--	-----	--
134	18.4	46.6	15.14	.005	29	.009	83	-----	--	.018	144	.028	53	.040	54	.053	47	.102	29	-----	--	-----	--	-----	--	-----	--
135	18.4	44.9	16.03	-----	--	.007	101	-----	--	.020	140	-----	--	.040	54	.051	54	.105	24	-----	--	-----	--	-----	--	-----	--
136	18.4	44.3	16.30	.003	42	.006	94	.011	82	.015	97	-----	--	.040	54	.050	54	.100	23	-----	--	-----	--	-----	--	-----	--
137	18.4	40.7	17.62	.002	49	.008	89	.011	53	.020	41	.029	20	.059	51	.076	44	.104	21	0.227	11	-----	--	-----	--	-----	--
138	18.4	40.4	17.69	.001	45	.006	106	.010	50	.017	48	.028	25	.059	57	.076	28	.098	17	.174	12	-----	--	-----	--	-----	--
139	18.4	40.7	17.74	.003	54	.007	117	.011	49	.019	55	.027	20	.040	53	.076	29	.099	23	.176	9	-----	--	-----	--	-----	--
140	18.4	36.1	19.45	.002	40	.007	45	.012	51	.015	49	.028	44	-----	--	-----	--	.105	19	.193	12	-----	--	-----	--	-----	--
141	18.4	35.5	20.02	.005	30	.006	49	.013	66	.020	57	.028	38	.041	28	.072	24	.103	15	-----	--	-----	--	-----	--	-----	--
142	18.4	35.4	20.73	.002	40	.006	54	.012	57	.019	59	-----	--	.049	28	.074	28	.102	15	-----	--	-----	--	-----	--	-----	--
																		.097	16	.166	13	-----	--	-----	--	-----	--
143	36.3	87.5	3.53	-----	--	.014	82	.029	97	.048	68	.071	73	.113	97	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
144	36.3	77.7	7.99	.005	45	.009	55	.015	63	.021	30	.050	63	.047	62	-----	--	.031	30	-----	--	-----	--	-----	--	-----	--
145	36.3	45.5	16.10	.002	41	.005	63	.011	87	.017	45	.024	67	.037	56	.042	44	.067	22	.134	20	-----	--	-----	--	-----	--
146	36.3	36.1	19.19	.001	27	.005	58	.011	35	.019	41	.029	58	.050	30	.042	30	.084	19	.129	18	0.171	15	0.340	9	-----	--
$\tau = 8^\circ$																									
147	18.4	84.9	3.55	0.014	78	0.028	85	0.044	58	-----	--	-----	--	0.122	19	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
148	18.4	79.0	6.89	.010	88	.024	95	.038	68	0.063	47	-----	--	.126	1	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
149	18.4	74.7	7.43	.010	71	.021	92	.033	60	.079	51	0.089	27	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
150	18.4	74.7	7.46	.010	77	.022	94	.037	61	.078	55	.093	24	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
151	18.4	75.0	7.50	.009	91	.020	92	.034	59	.071	54	.083	32	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
152	18.4	62.9	11.15	.007	103	.016	87	.026	73	.041	50	-----	--	.085	35	0.150	29	-----	--	-----	--	-----	--	-----	--	-----	--
153	18.4	44.2	15.76	.009	68	.012	58	.027	44	.041	30	-----	--	.061	21	.110	21	-----	--	-----	--	-----	--	-----	--	-----	--
154	18.4	41.6	17.41	.007	47	.017	54	.027	36	.042	27	.057	17	.079	24	.071	18	-----	--	-----	--	-----	--	-----	--	-----	--
155	18.4	41.4	17.44	.007	47	.014	57	.025	37	.039	30	.043	14	.074	24	.104	22	-----	--	-----	--	-----	--	-----	--	-----	--
156	18.4	40.6	17.61	.007	49	.015	56	.026	37	.039	32	.053	17	.074	31	.102	18	-----	--	-----	--	-----	--	-----	--	-----	--
157	18.4	37.0	18.31	.006	43	.011	51	.024	39	.041	24	-----	--	.073	31	.106	12	-----	--	-----	--	-----	--	-----	--	-----	--
$\tau = 14^\circ$																									
158	18.4	84.3	4.17	0.020	42	0.044	71	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
159	18.4	74.7	7.93	.014	64	.030	93	0.056	53	0.100	50	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
160	18.4	74.4	7.91	.014	65	.036	93	.058	52	.100	51	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
161	18.4	73.7	8.04	.011	64	.029	90	.056	50	.107	50	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
162	18.4	58.5	8.40	.013	56	.040	52	.064	51	.090	34	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
163	18.4	58.7	12.55	.010	45	.029	50	.044	36	.069	29	0.109	28	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
164	18.4	44.2	15.89	.010	40	.024	42	.040	30	.061	25	.084	24	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
165	18.4	41.0	17.84	.011	39	.023	40	.040	24	.060	21	.081	13	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
166	18.4	41.2	17.84	.012	39	.024	40	.040	26	.058	19	.079	8	0.110	16	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
167	18.4	40.8	18.03	.011	38	.025	41	.039	26	.057	24	.079	10	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--
168	18.4	36.0	19.57	.011	32	.024	33	.039	23	.060	20	.080	20	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--	-----	--

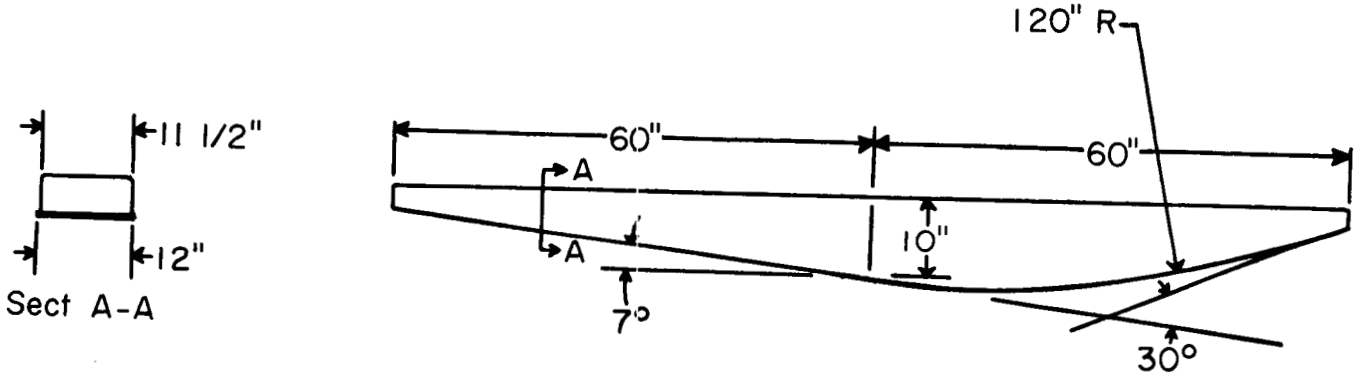
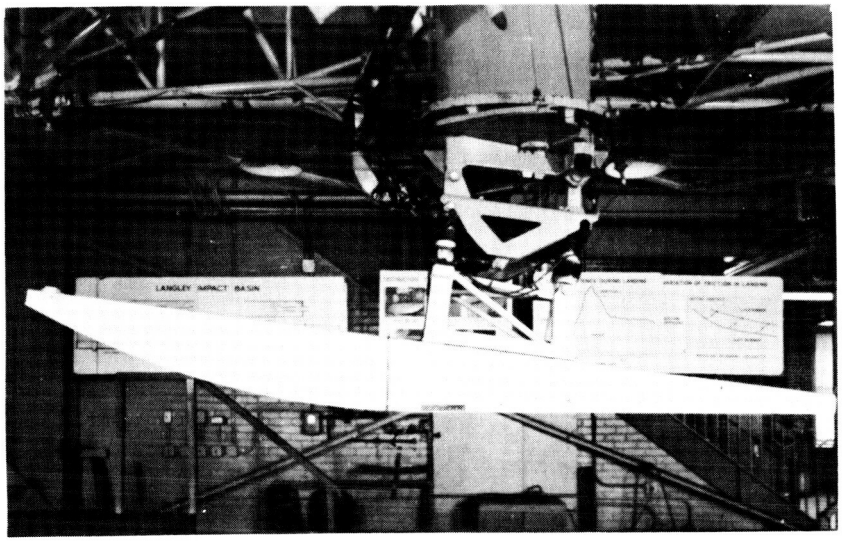


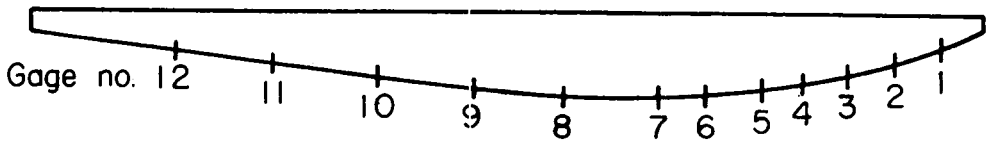
Figure 1.- Profile showing pertinent dimensions of model.



(a) Curved-bow configuration at 0° trim.

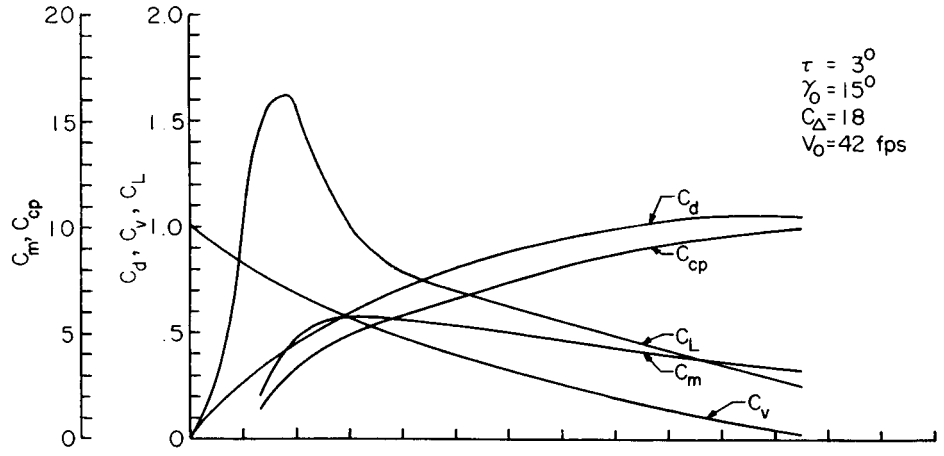
(b) Curved-stern configuration at 0° trim. L-59-6464

Figure 2.- Photographs of model mounted for testing.

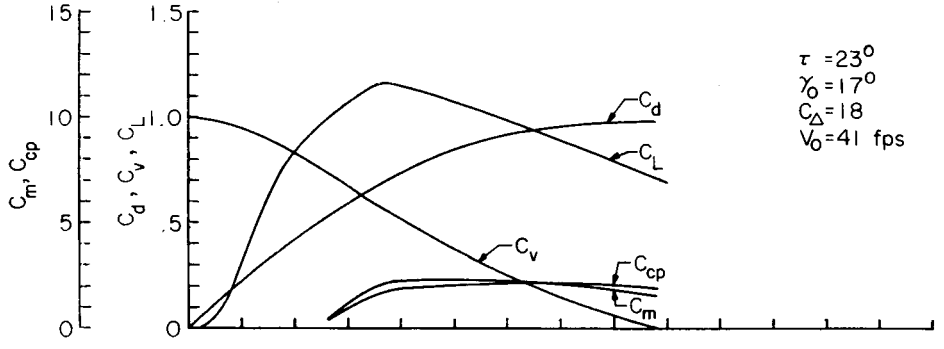


Trim, deg	Draft, feet at pressure gage:											
	1	2	3	4	5	6	7	8	9	10	11	12
16	0.16	0.34	0.54	0.77	0.97	1.29	1.57	2.21	2.87	3.59	4.37	5.11
8	.09	.20	.33	.49	.62	.89	1.12	1.65	2.20	2.82	3.50	4.12
0	.02	.06	.13	.22	.31	.47	.63	1.04	1.48	1.98	2.53	3.03
-8	.04	.01	0	.02	.06	.14	.23	.50	.82	1.19	1.59	2.22
-14	.17	.09	.04	.01	0	.02	.07	.24	.48	.76	1.06	1.34
-22	.53	.38	.26	.15	.09	.03	.01	.03	.15	.29	.45	.59
Distance along bottom from step, ft	0.50	1.00	1.50	2.00	2.42	3.00	3.50	4.50	5.42	6.42	7.50	8.50

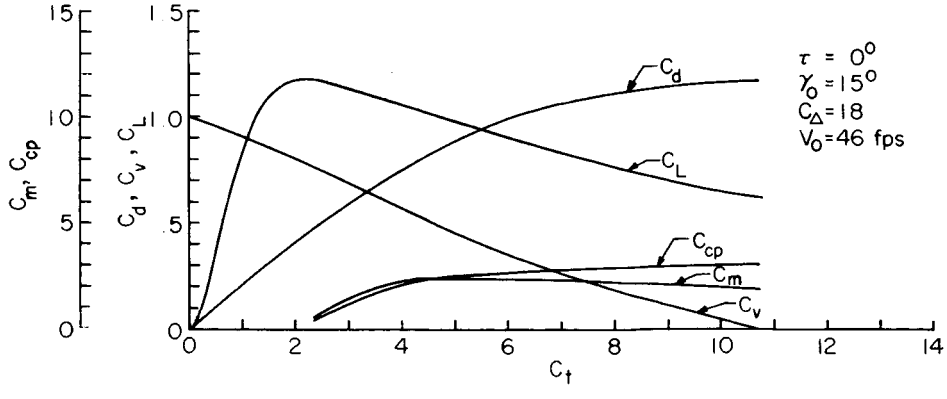
Figure 3.- Pressure-gage locations.



(a) Run 27, curved-bow configuration.

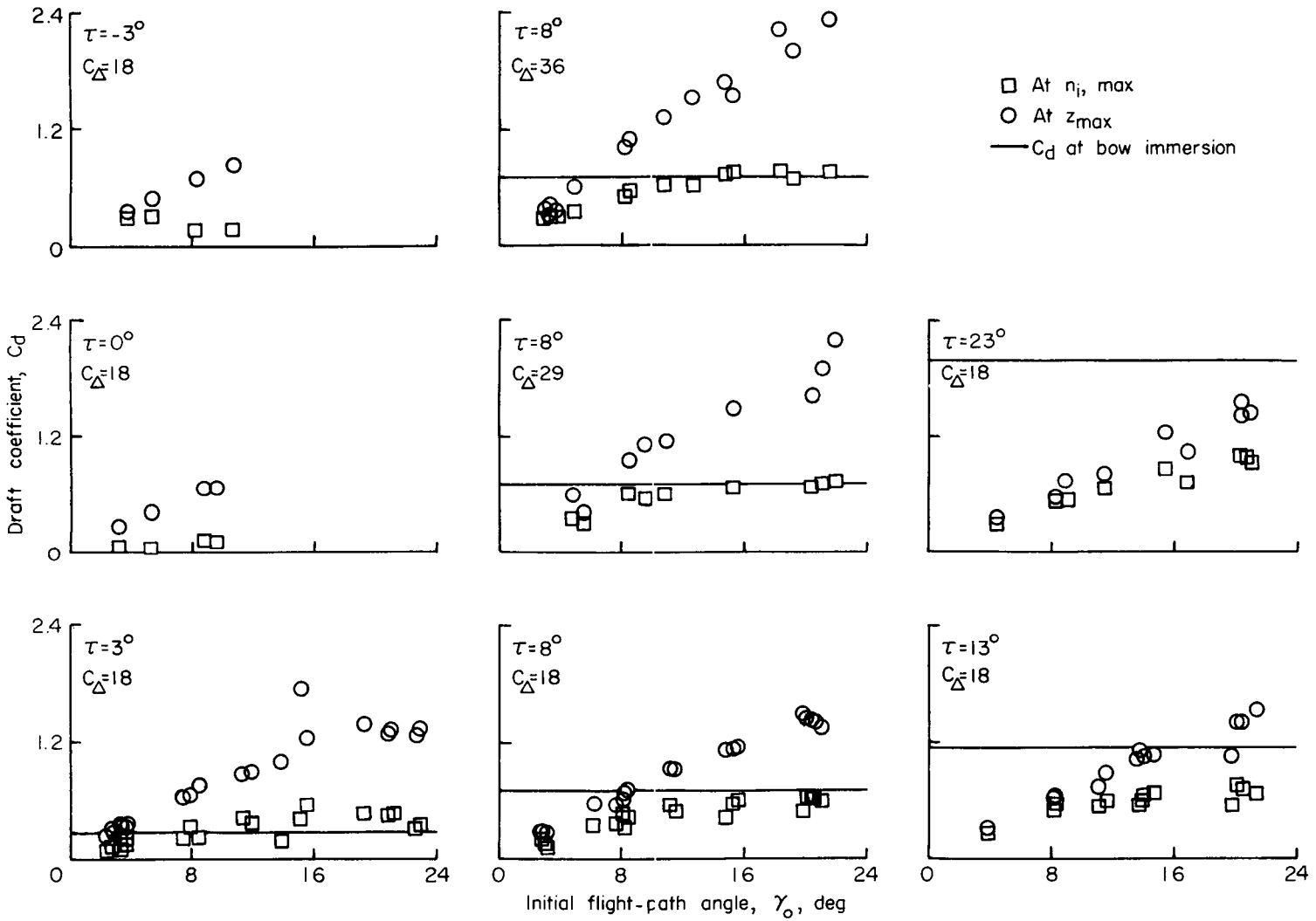


(b) Run 70, curved-bow configuration.



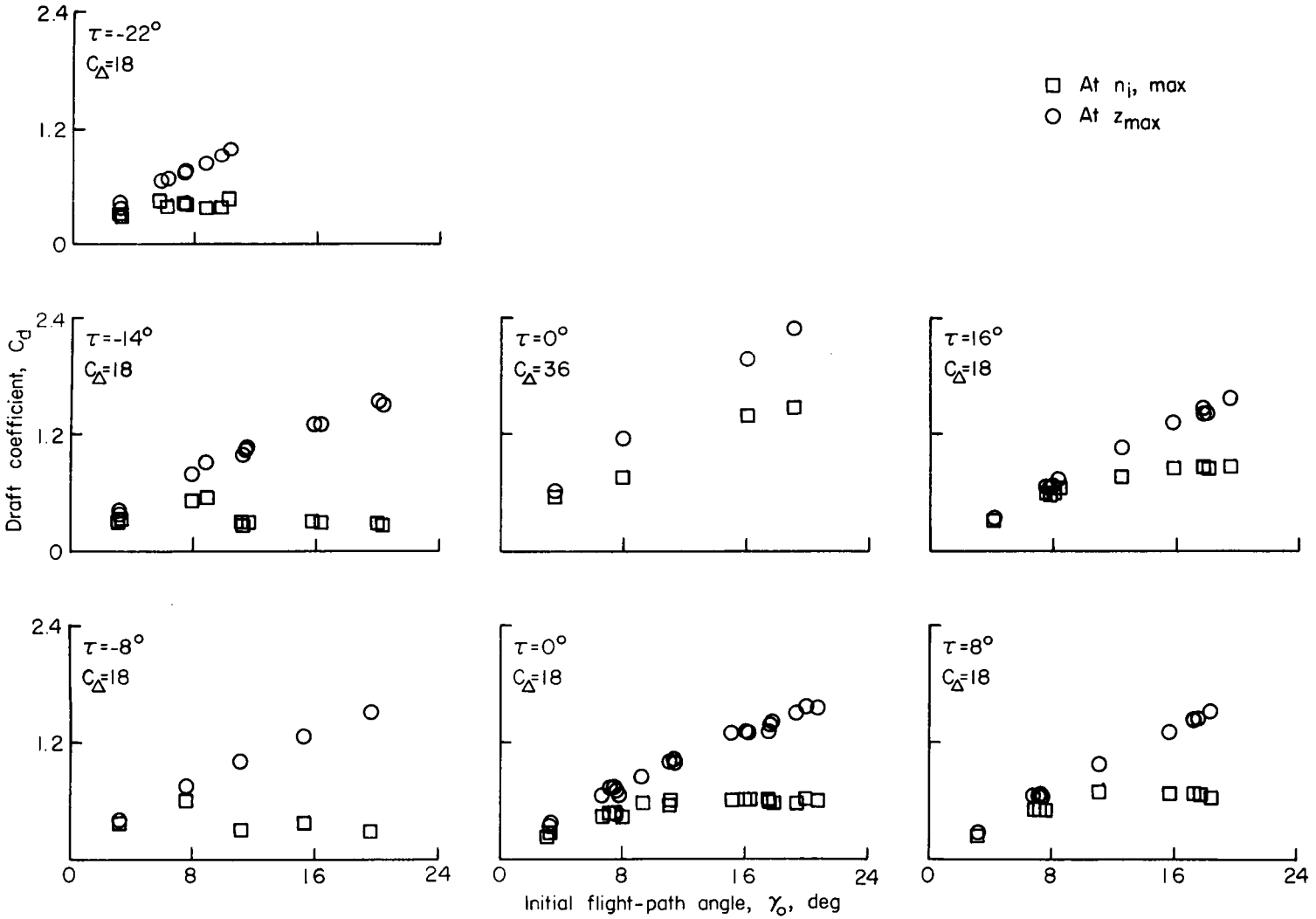
(c) Run 134, curved-stern configuration.

Figure 4.- Time histories of typical runs.



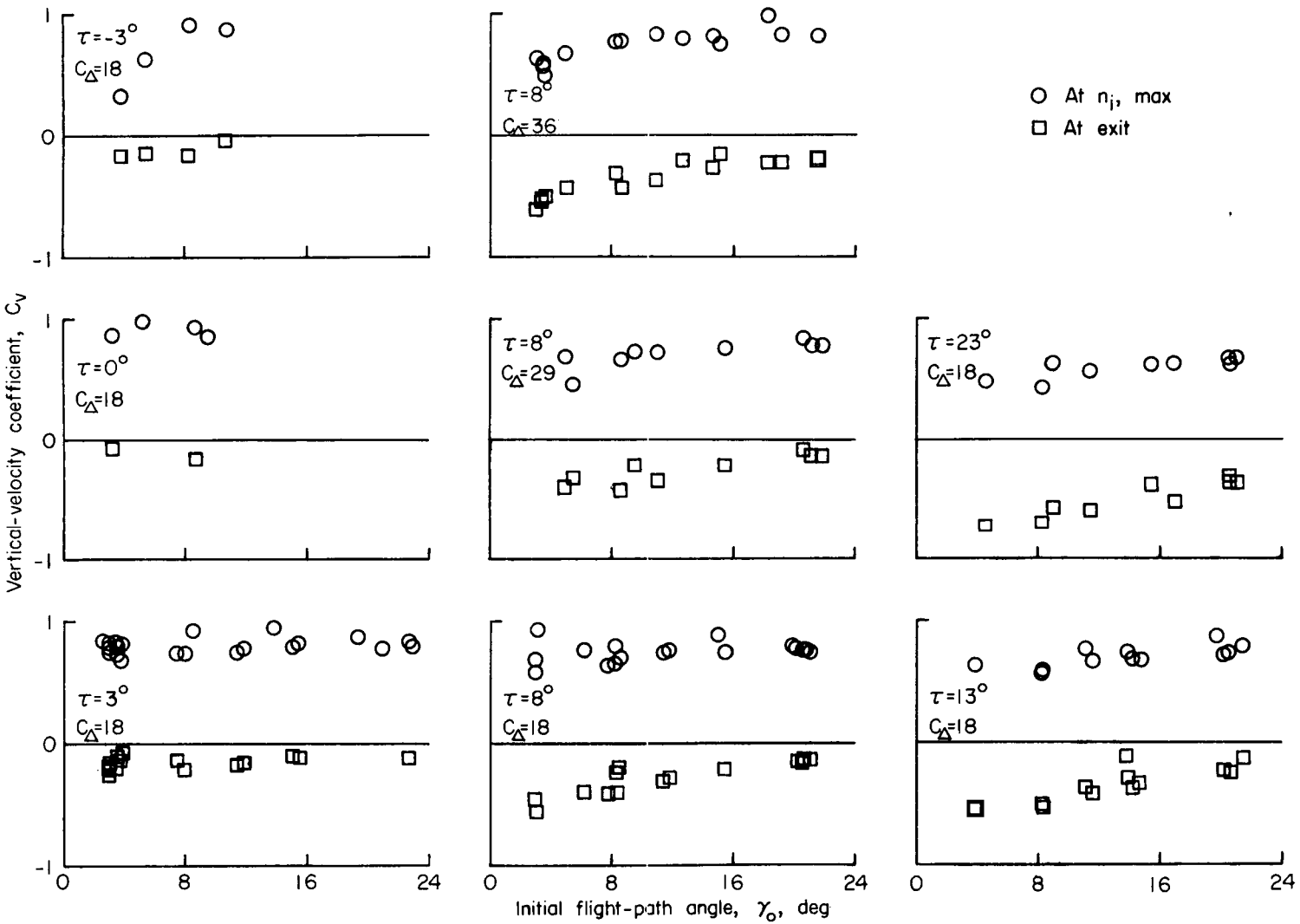
(a) Curved-bow configuration.

Figure 5.- Experimental variation of draft coefficient with initial flight-path angle.



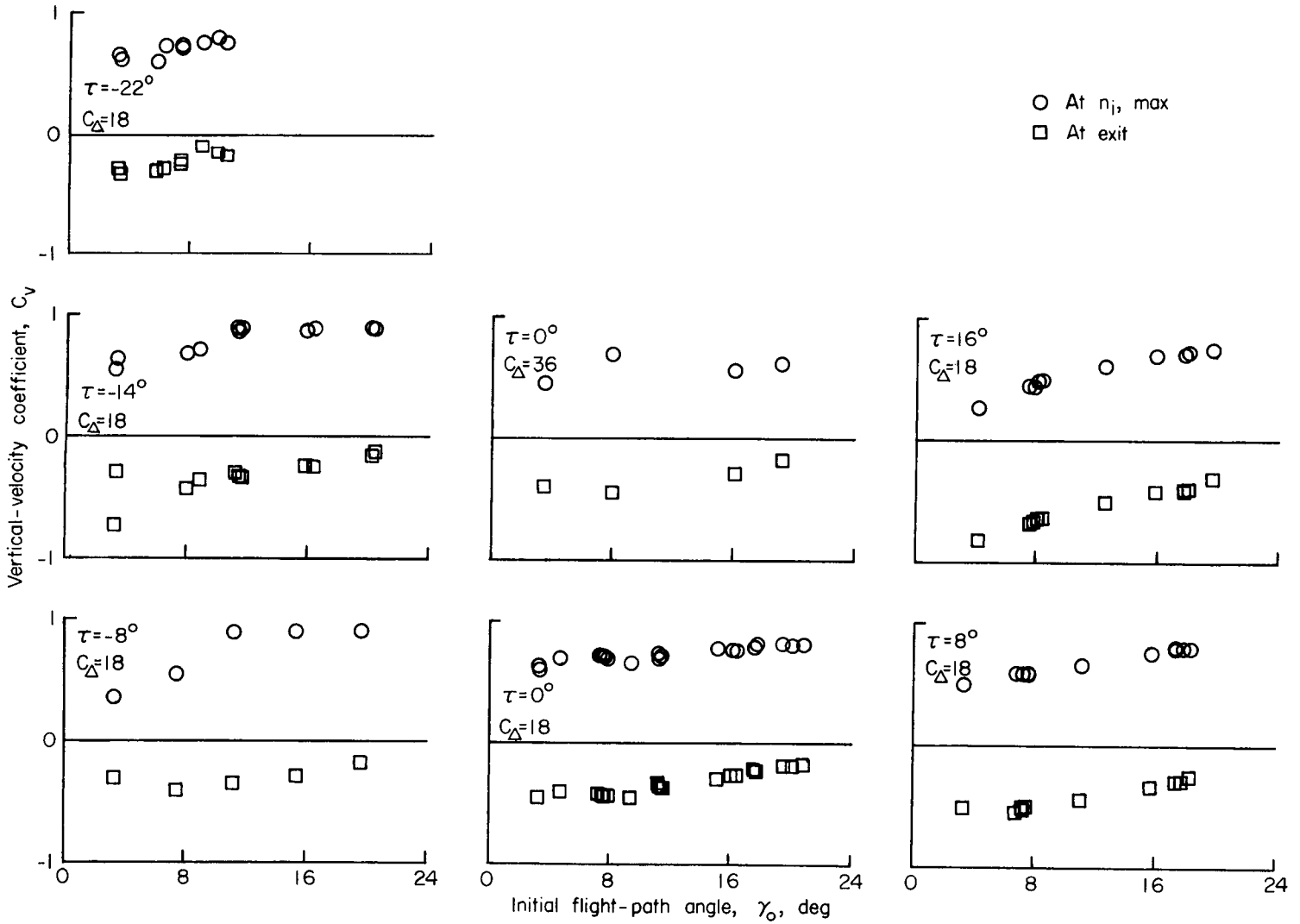
(b) Curved-stern configuration.

Figure 5.- Concluded.



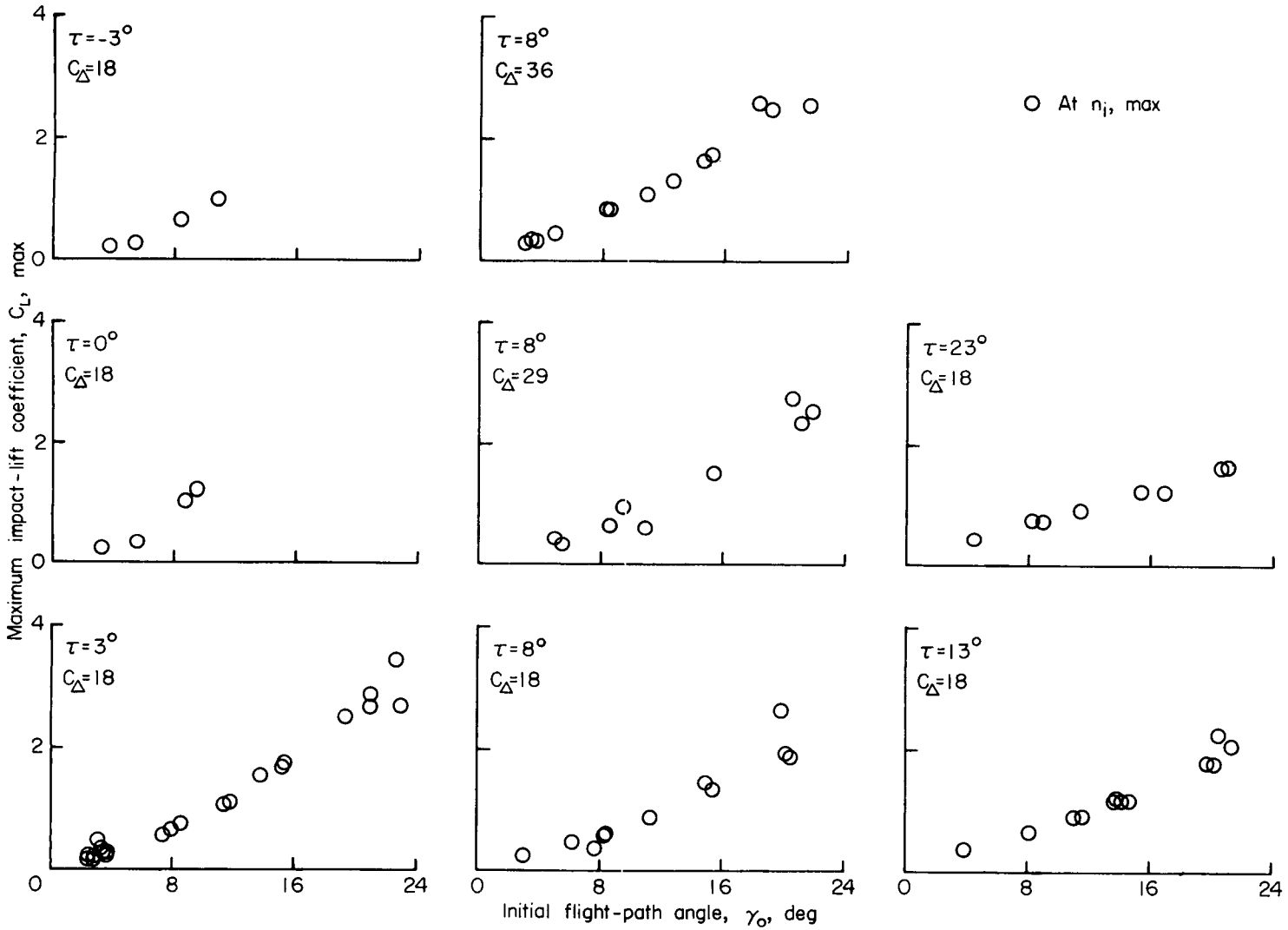
(a) Curved-bow configuration.

Figure 6.- Experimental variation of vertical-velocity coefficient with initial flight-path angle.



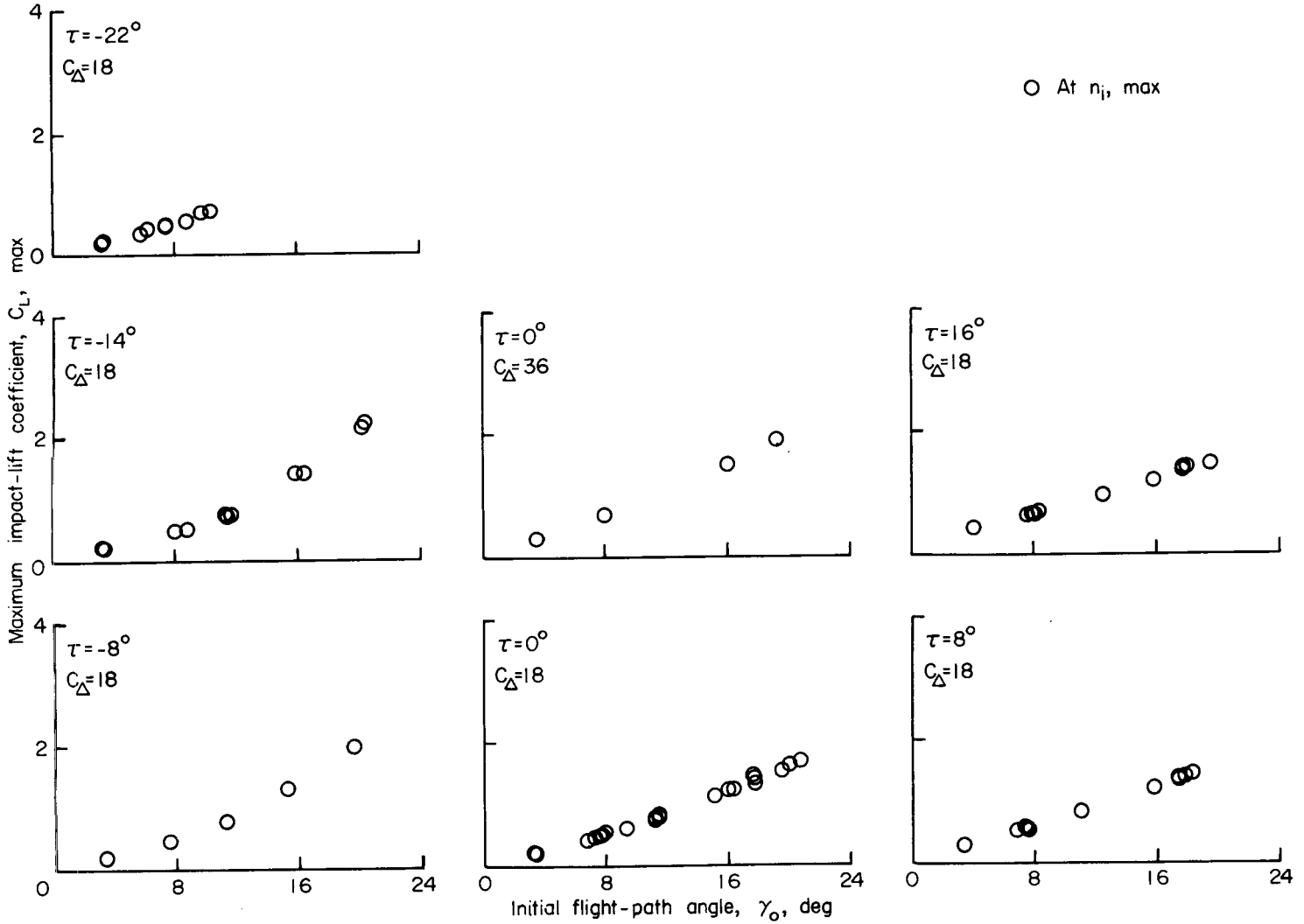
(b) Curved-stern configuration.

Figure 6.- Concluded.



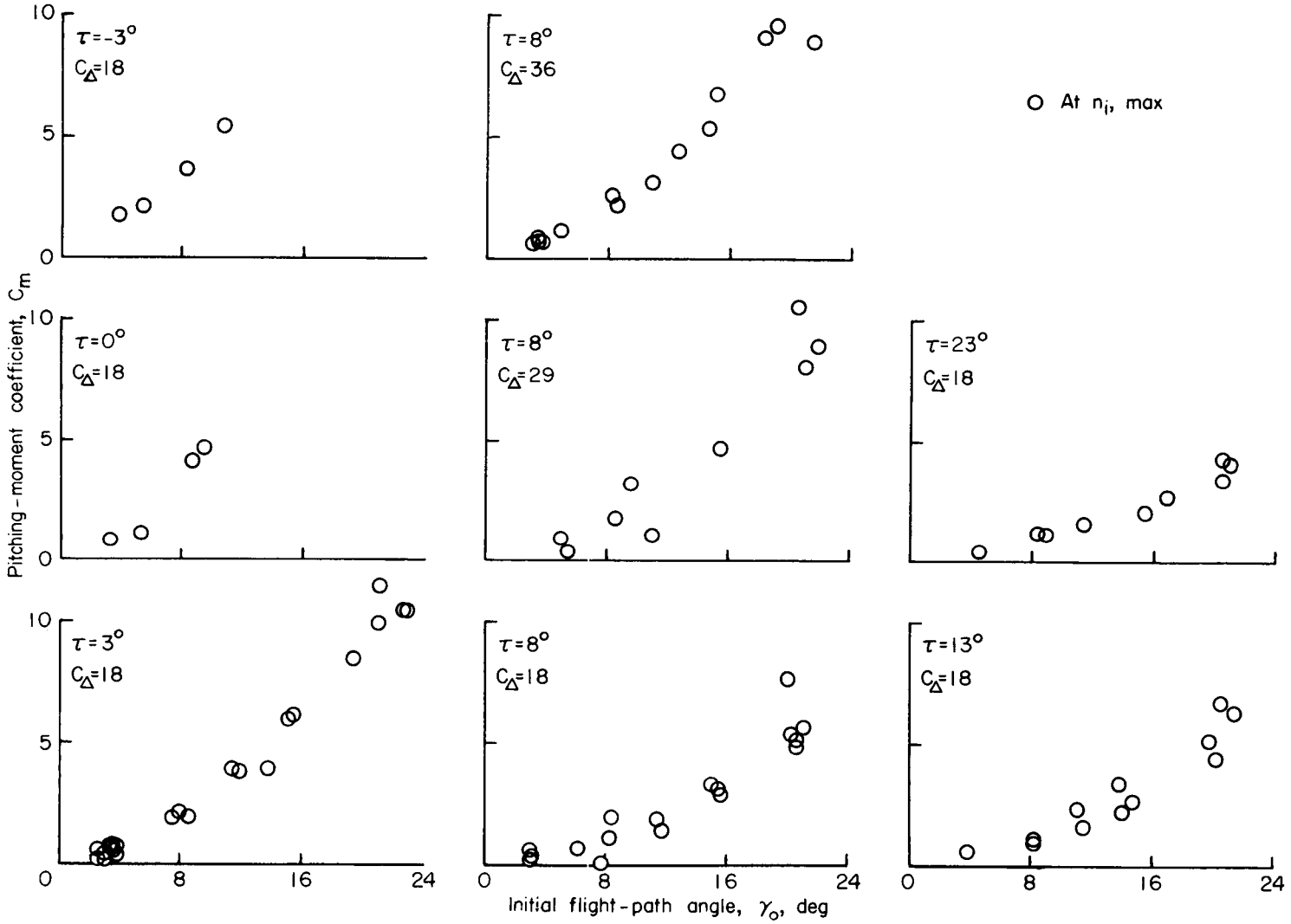
(a) Curved-bow configuration.

Figure 7.- Experimental variation of maximum-impact lift coefficient with initial flight-path angle.



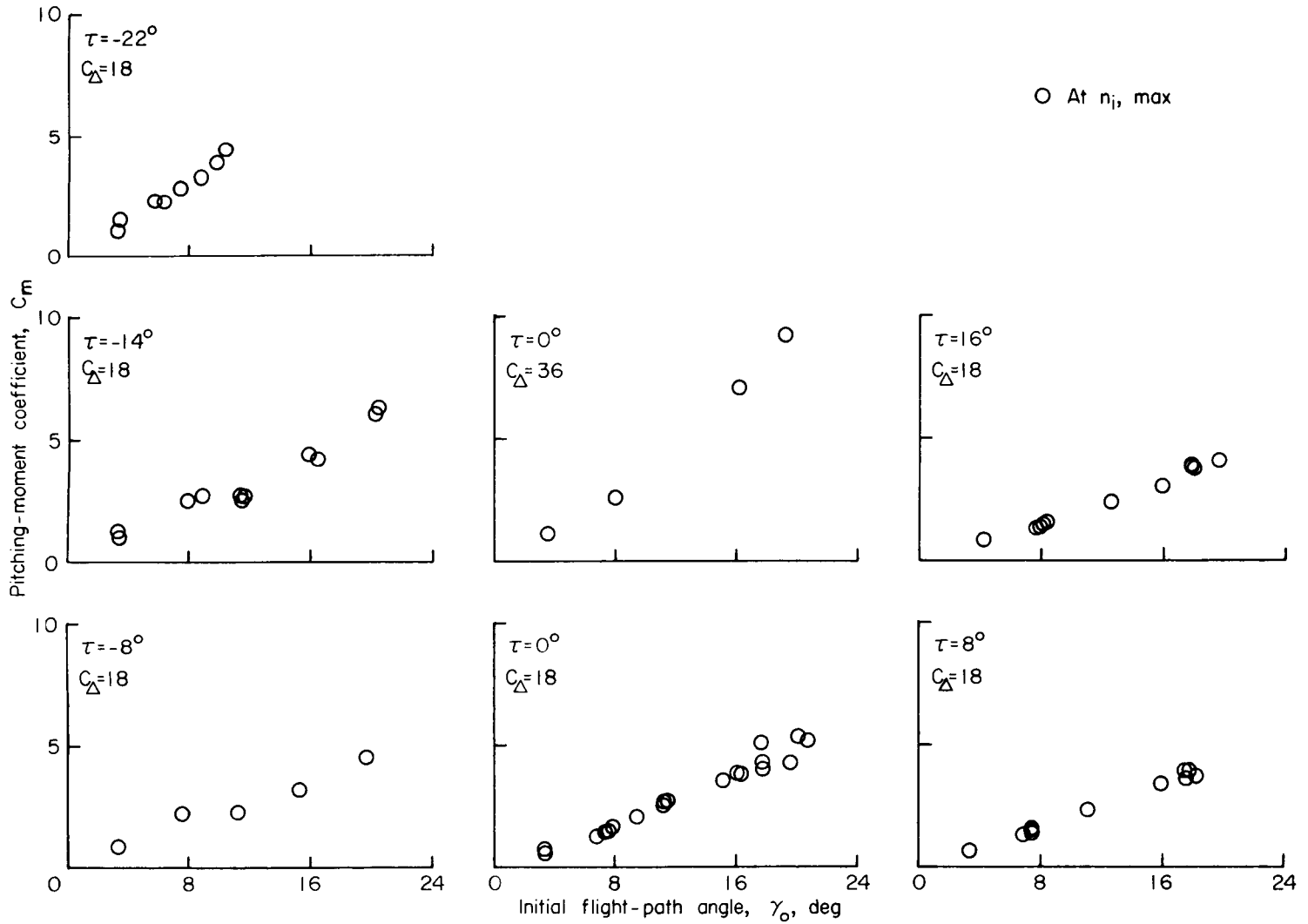
(b) Curved-stern configuration.

Figure 7.- Concluded.



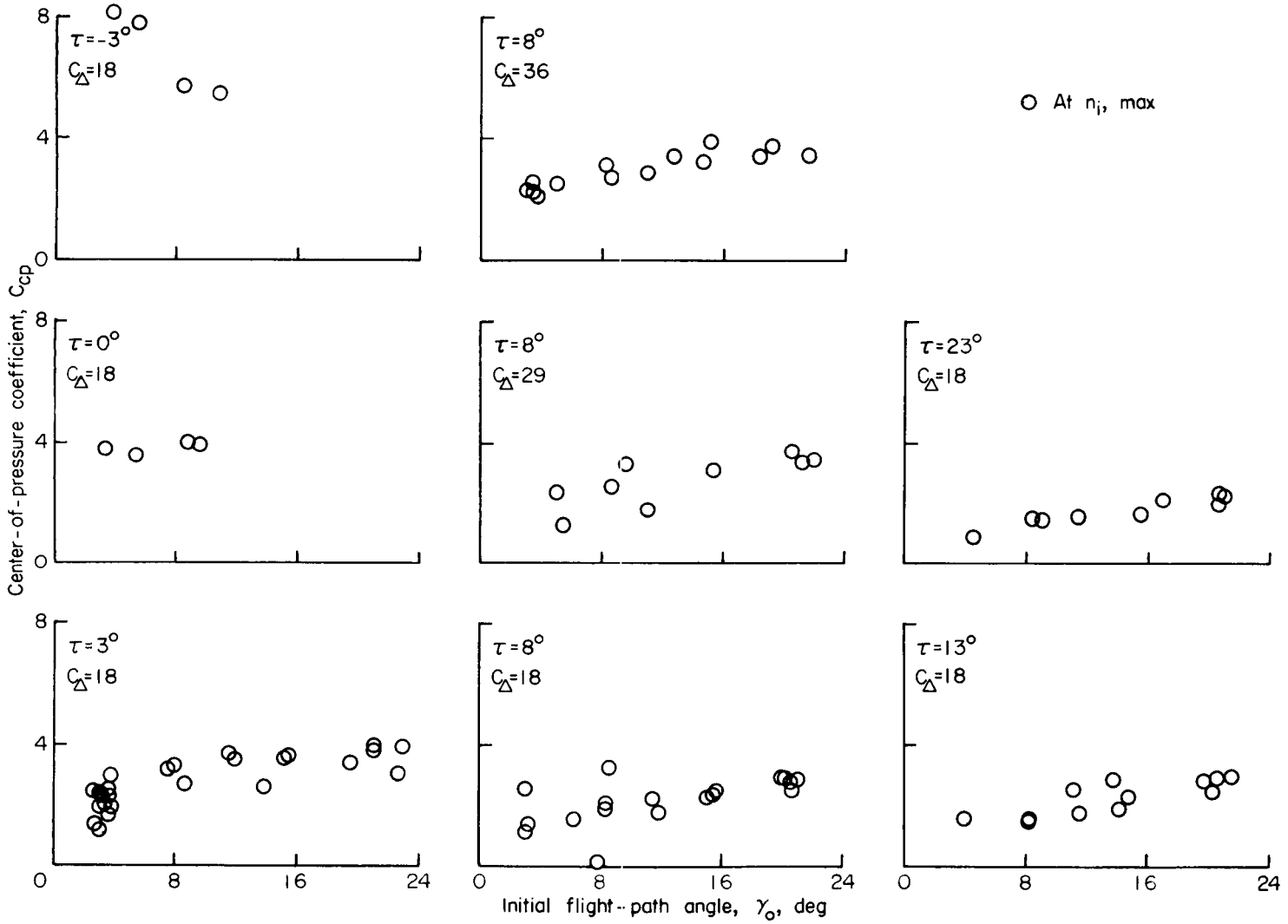
(a) Curved-bow configuration.

Figure 8.- Experimental variation of pitching-moment coefficient with initial flight-path angle.



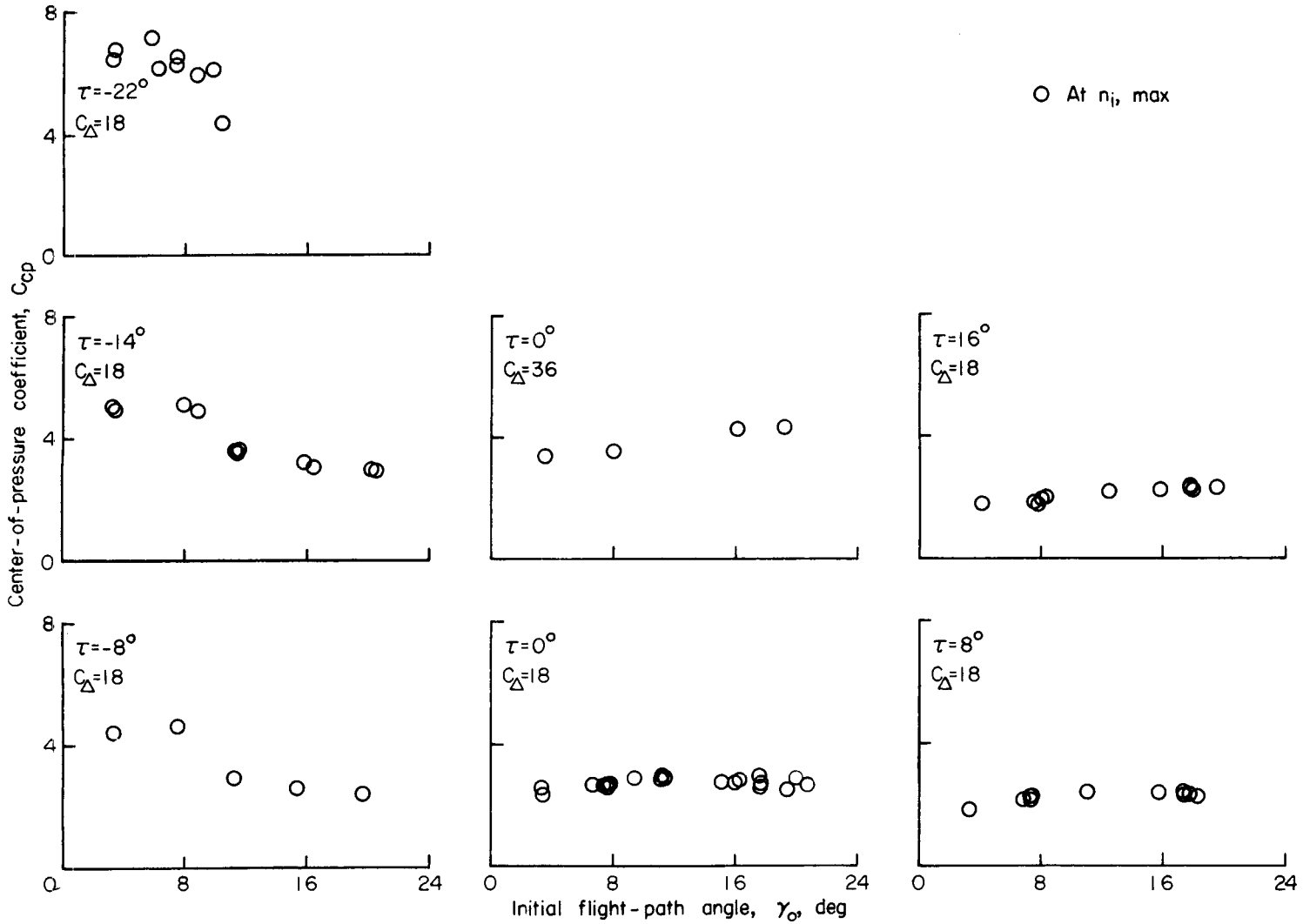
(b) Curved-stern configuration.

Figure 8.- Concluded.



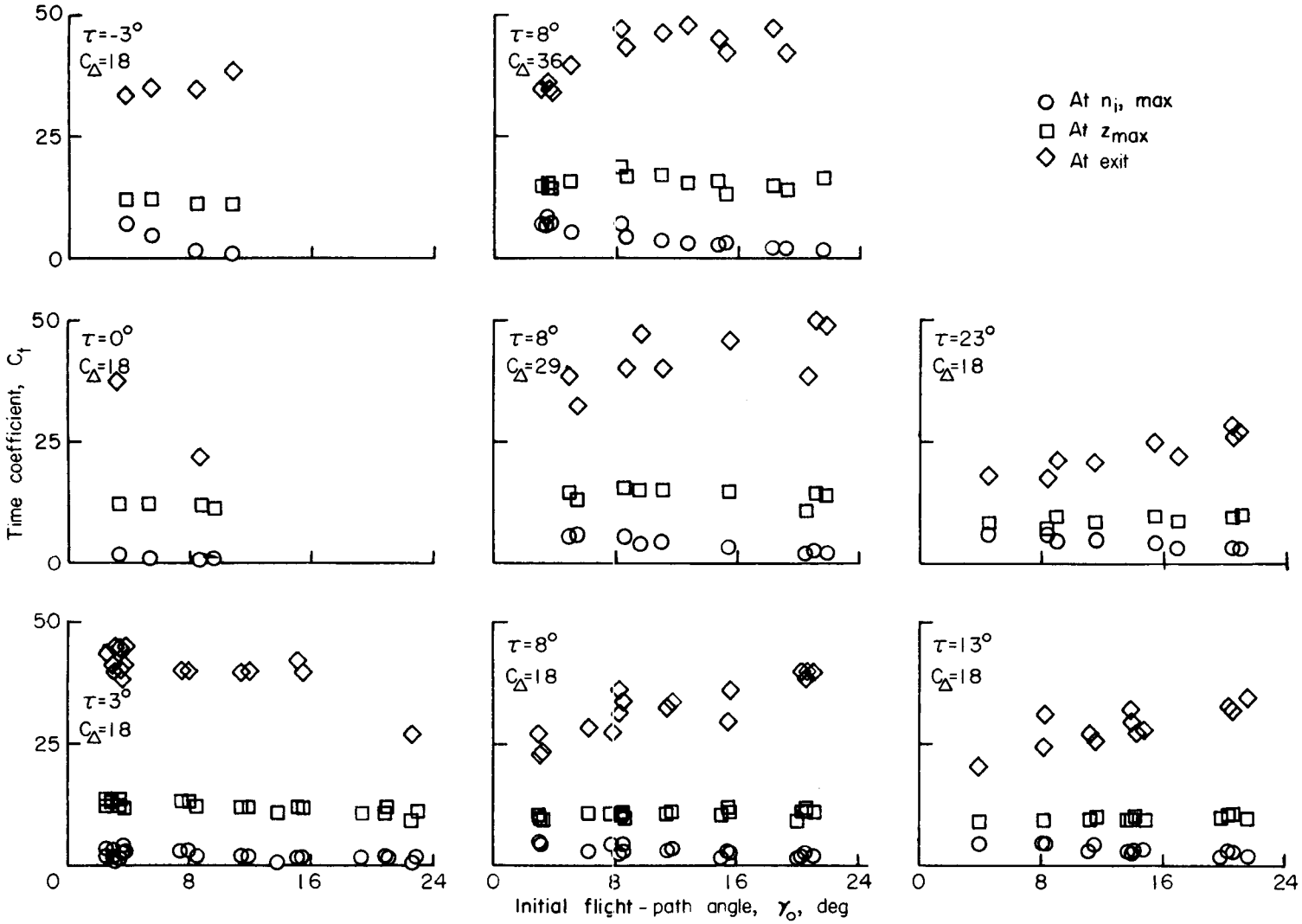
(a) Curved-bow configuration.

Figure 9.- Experimental variation of center-of-pressure coefficient with initial flight-path angle.



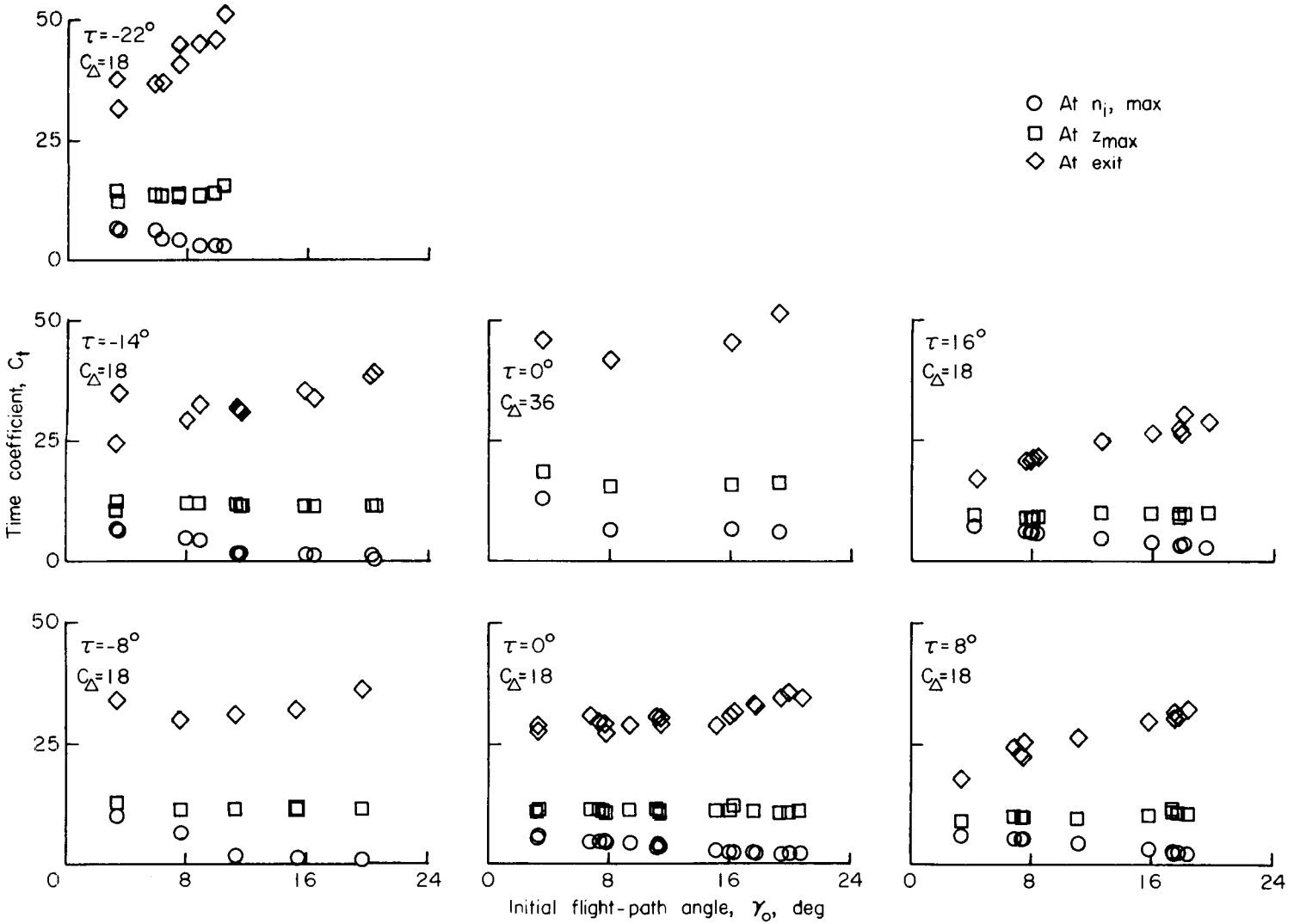
(b) Curved-stern configuration.

Figure 9.- Concluded.



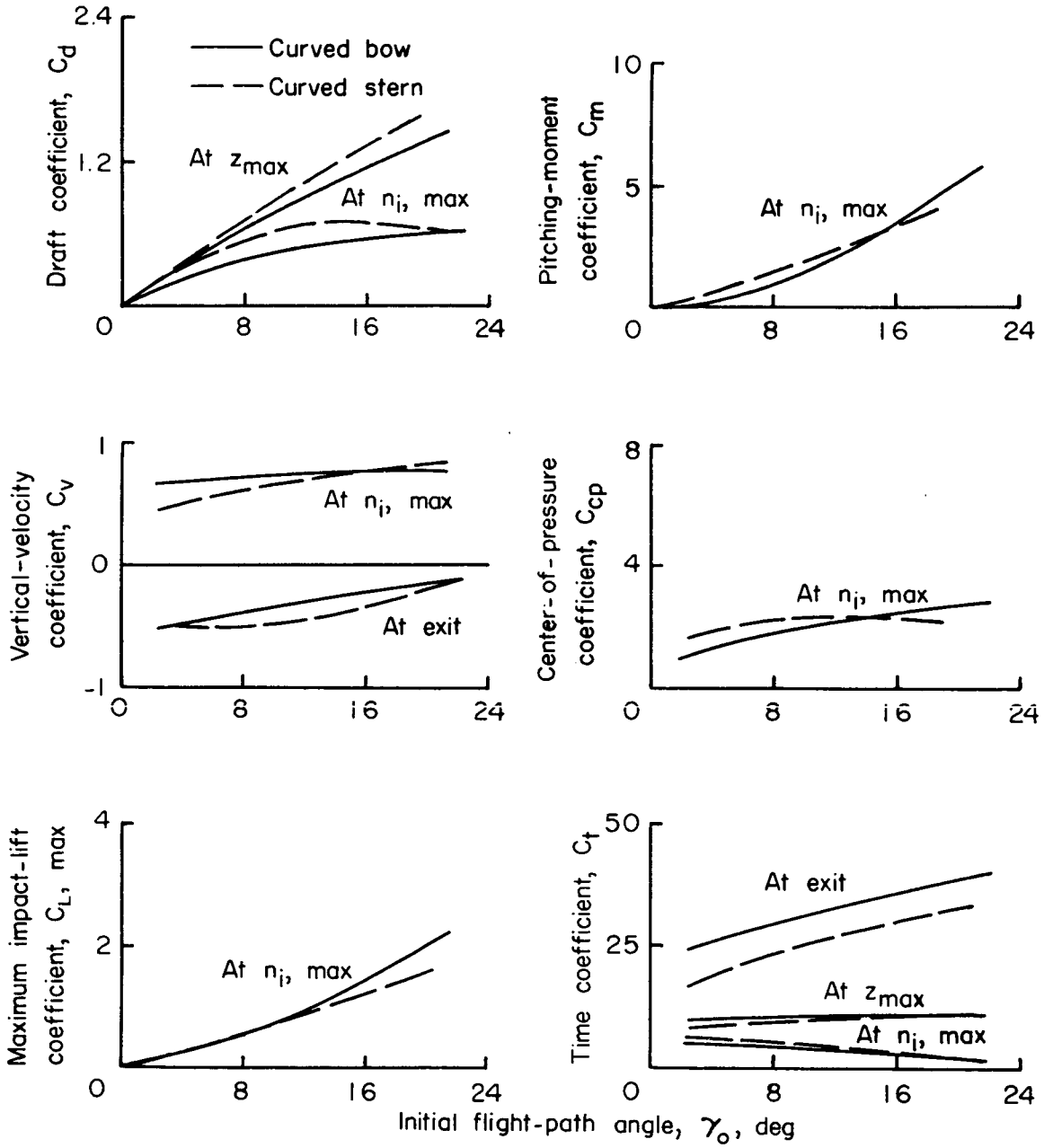
(a) Curved-bow configuration.

Figure 10.- Variation of time coefficient with initial flight-path angle.



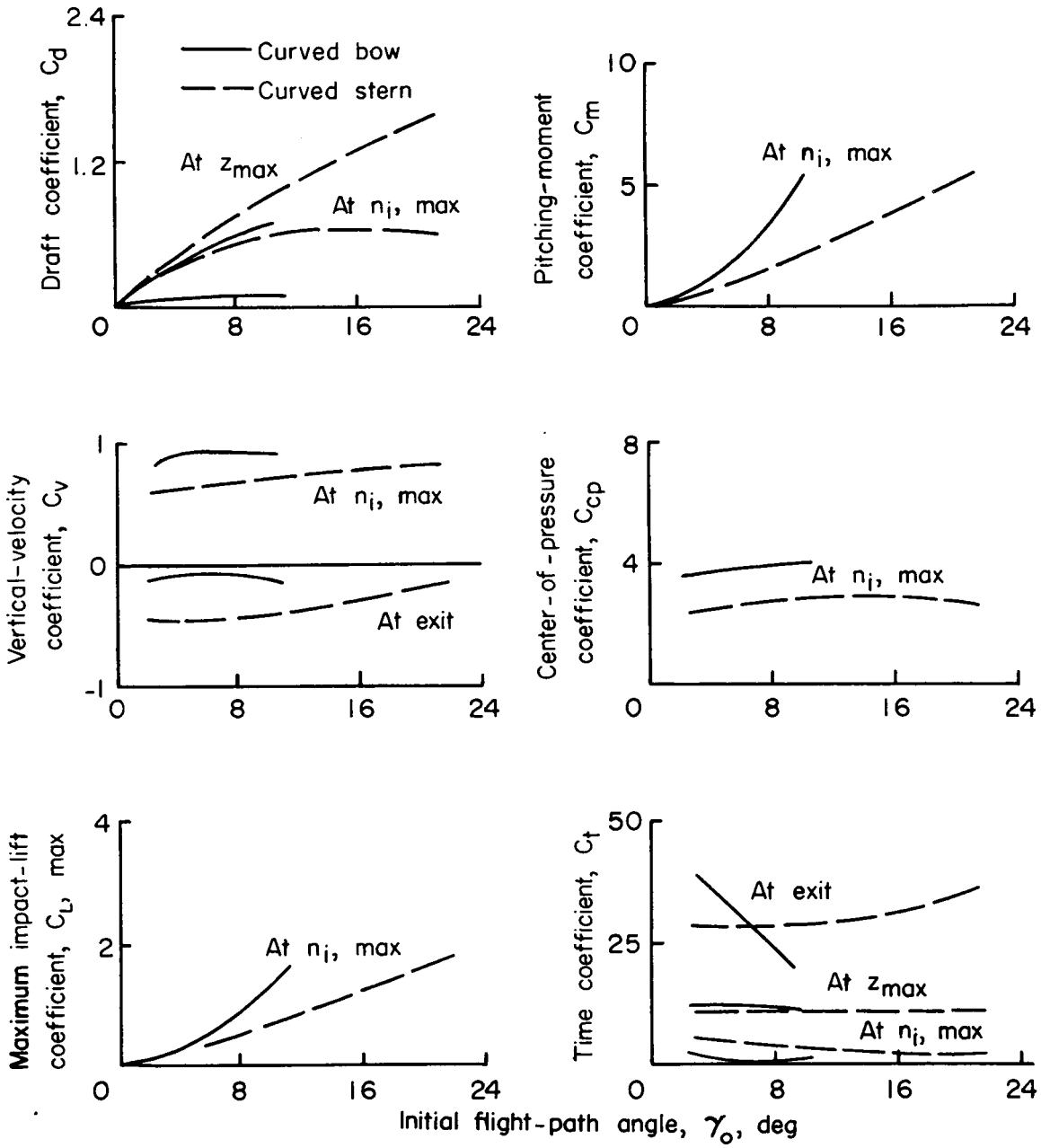
(b) Curved-stern configuration.

Figure 10.- Concluded.



(a) $\tau = 8^o$; $C_\Delta = 18$.

Figure 11.- Comparison of variation of coefficients with initial flight-path angle for curved-bow configuration and curved-stern configuration.



(b) $\tau = 0^{\circ}$; $C_{\Delta} = 18$.

Figure 11.- Concluded.